The Routledge Companion to Innovation Management

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Innovation and innovation management

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INNOVATION AND INNOVATION MANAGEMENT

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Value of innovation

Innovation and human development

The history of mankind is one of innovation, especially our great economic leaps over the past two centuries (Fu and Gong, 2011). The Renaissance in the 14th century shattered backward thoughts by introducing new thinking. The navigation rush in the 15th century expanded the bounds of human civilization. The scientific revolution, which began in the 16th century, laid the foundation for the technological revolution. The capital market, which was born in the beginning of the 17th century, made financial activities a widespread phenomenon in society. The Industrial Revolution, which began in the 18th century, gave a great impetus to economies around the world. Although current economic theories and other doctrines fail to explain all these phenomena perfectly, many scholars have identified a common factor – innovation – in the chain of historical events (Chen, 2017b).

Alec Foege, author of *The Tinkerers: The Amateurs, DIYers, and Inventors Who Make America Great*, referred to innovators – amateurs, DIYers and inventors who enjoyed fiddling with small devices and inventions – as "tinkerers" (meaning "工匠" when translated into Chinese), to whom he attributed the miracle of America: "American tinkerers are a group of independent people who make world-changing inventions and innovations with sheer willpower and tenacity". For example, Benjamin Franklin, Eli Whitney, Cyrus McCormick, Thomas Edison and the Wright brothers were outstanding innovators in human history. Such inventors come these days from emerging markets like India ("jugaad") and Brazil ("gambiarra") but also from China (Agarwal, Grottke, Mishra, and Brem, 2017; Wimschneider, Agarwal, and Brem, 2018).

There, a new round of technological and industrial revolutions is forthcoming as a radical change in the global industrial structure and competition pattern begins to arise (Chen, Zhao, and Wang, 2014). Disruptive innovations that may make a breakthrough in the future are of great importance to our "technology-economy-society" pattern (Christensen, Baumann, Ruggles, and Sadtler, 2006).

The National Economic Council and the Office of Science and Technology Policy issued the newest version of the Strategy for American Innovation at the end of October 2015, announcing the commitment to the development of nine strategic areas (as shown in Table 1.1).

Table 1.1 Nine strategic areas in the Strategy for American Innovation

S. No.	*Area*	*Description*
11	Advanced manufacturing	A National Network for Manufacturing Innovation will be launched to restore the nation's lead at the cutting edge of manufacturing innovation.
22	Precision medicine	Precision medicine will boost developments in genomics, large data sets and health information technology while protecting privacy. It gives clinicians tools to better understand the complex mechanisms underlying a patient's health, disease or condition and to better predict which treatments will be most effective.
33	Brain initiative	A deepened knowledge of how brains work, based on genetics, will help scientists and doctors diagnose and treat neurological disorders.
44	Advanced vehicles	Breakthrough developments in sensing, computing and data science will bring vehicle-to-vehicle communication and cutting-edge autonomous technology safety features into commercial deployment.
55	Smart cities	An emerging community of civic leaders, data scientists, technologists and companies are joining forces to build "smart cities".
66	Clean energy and energy-efficient technologies	The administration will continue to deploy and develop clean energy technologies, fund climate-change solutions and increase new energy production while improving America's energy security.
77	Educational technology	The president has proposed to give 99 percent of students access to high-speed broadband by 2018. And the 2016 budget includes $50 million for the creation of an Advanced Research Projects Agency for Education.
88	Space	America will make core investments in the development of commercial crew space transportation capability by 2017. America will also invest in research on the protection of astronauts from space radiation, on advanced propulsion systems and on technologies that allow humans to live in outer space.
99	New frontiers in computing	In July 2015, the president created the National Strategic Computing Initiative to spur the creation and deployment of computing technology at the leading edge, helping advance administration priorities for economic competitiveness, scientific discovery and national security.

In May 2013, McKinsey Global Institute released *Disruptive Technologies: Advances That Will Transform Life, Business and the Global Economy by 2025*,[1] a report that estimated the direct impact of these technologies on the global economy between $14 and $33 trillion. Table 1.2 provides the details on the major technologies and areas.

Innovation and national/regional competitiveness

Currently scientific progress and innovation play a decisive role in economic and social development in the world (Chen, Yin, and Mei, 2018). An entity, whether as big as a country or as small as an enterprise, will miss the opportunity of proactive future development if it fails to grab

Table 1.2 Twelve disruptive technologies

S. No.	*Area*	*Description*	*Potential economic impact on the world by 2025*
11	Mobile Internet	Smaller, viewable, wearable and more powerful mobile computing devices with more sensors benefit consumers with improved medical and educational services, and elevate employee productivity.	$373 mln-$10.8 tln
22	Automation of knowledge work	This automation technology applies primarily to ordinary business operation (e.g. marketing, customer service and administrative support), social services (e.g. education and medical care), technology industries (e.g. science, engineering and IT) and professional services (law and finance).	$523 mln-$6.7 tln, equivalent to 120 mln-140 mln full-time jobs
33	IoT (Internet of Things)	IoT has the biggest economic impact on medical care and manufacturing. It is also applied to smart grids, urban infrastructure, resource exploitation, agriculture and automobiles.	$273 mln-$6.2 tln
44	Cloud	Cloud technology means a simpler, faster, more powerful and more efficient digital world that creates great value for consumers as well as enterprises, which can manage information more efficiently and flexibly.	$173 mln-$6.2 tln
55	Advanced robotics	Advanced robotics covers primarily industrial robotics, surgical robotics, exoskeleton robotics, prosthetic robotics, service robotics and domestic robotics.	$173 mln-$4.5tln
66	Autonomous and near-autonomous vehicles	Safer, less congestion, more time savings, less fuel consumption and less emissions.	$23 mln-$1.9 tln; can save 30,000–150,000 lives
77	Next-generation genomics	Next-generation genomics quickens advances in biology and applies primarily to the diagnosis and treatment of diseases, agriculture and biofuel production.	$70 mln-$1.6 tln
88	Energy storage	The technology applies primarily to electrical/hybrid vehicles, distributed energy, utilities and energy storage.	$90 bln-$635 bln
99	3D printing	Major applications include consumers, direct product manufacturing, tool and die making and bioprinting of tissue and organs.	$230 bln-$550 bln
110	Advanced nanomaterials	Advanced nanomaterials have found extensive application in medical care, electronics, composite materials, solar cells, desalination and catalyzers, but the cost is higher. Nanomedical materials have very great potential to be used for targeted cancer therapy.	$150 bln-$500 bln
111	Advanced oil and gas exploration and recovery	Shale gas and light crude oil exploration and recovery, primarily in North America.	$95 bln-$460 bln
112	Renewable energy	By 2025 wind power and solar power may increase from 2% to 16% of global electricity generation.	$165 bln-$275 bln; equivalent to 1 bln to 1.2 bln less tons of carbon emissions

Source: Chunping (2016).

self-developed core technology or intellectual property (IP) assets instrumental in innovation activities. Economists have attributed the fast growth of the world economy following World War II to a push for technological innovation.

Innovation has been widely recognized as the main driver and first impetus for a sustainable regional or national economic growth, as well as global competency (Acs, Audretsch, Lehmann, and Licht, 2017; Brem and Viardot, 2017). Especially for those emerging economies, it's no longer a useful tool for them to depend on international trade or labor-intensive work such as manufacturing. The marginal benefit from labor investment is decreasing, while the returns of investment in new technology are increasing, which becomes a new driving force for the emerging economics to obtain a competitive advantage in the global market (Aguirre-Bastos and Weber, 2018). Both developed and developing countries are trying to build up their national innovation system in order to cultivate creative talents, high-tech based start-ups and new technology that could be translated into sustainable power for industrial upgrading and economic growth (Chen, 2017a). This is also the main reason why Asian countries such as South Korea, Japan, China and India continue to increase their domestic expenditure on research and development (R&D), sharing the largest proportion of the worldwide R&D expenditure, about 42.9 percent in 2017, according to the 2017 Annual Global R&D Funding Forecast.[2] For example, South Korea ranks number one in national innovation competitiveness among all the countries in 2018, according to the 2018 Bloomberg Innovation Index.[3] China moved up two spots to 19th, buoyed by its high proportion of new science and engineering graduates in the labor force and an increasing number of patents by innovators such as Huawei Technologies Co., and is the first-ever developing country who gets a position in the top 20 most innovative countries in history.

Innovation is a double-edged sword in terms of social impact (Martin, 2016). On the one hand, many innovative products make our life better. For example, the plane and the high-speed rail make travel faster, and Apple smart devices have changed our lifestyle fundamentally. A large number of new products and services are delivered to every corner of the world. An increasing share of the public can have access to more plentiful food, life necessities and better medical services.

But innovation means possible negative effects as well. For example, industrial technologies may cause pollution, agricultural and fishing technologies may aggravate ecological problems and medical technologies may involve drug-resistance problems and bioethical issues (like genetic engineering). However, technology is essentially a knowledge-based means of solving problems and achieving goals. Overall, innovation, if effectively managed, will minimize its negative effects to better serve mankind, in which case we call it an inclusive innovation or responsible innovation (George, McGahan, and Prabhu, 2012; Stilgoe, Owen, and Macnaghten, 2013; Timmermans, Yaghmaei, Stahl, and Brem, 2017).

Innovation and corporate competitiveness

Innovation creates inexhaustible energy for corporate existence and development

The global competition pattern is now reducing down to economic and technology competition, which is increasingly drawing momentum from technological innovation (Chen, Yin, and Zhao, 2019; Kumpe and Bolwijn, 1994). More and more firms have found high production efficiency, quality and even flexibility to be insufficient to maintain competitive advantages. Instead, innovation is increasingly creating an inexhaustible energy for corporate existence and development (see Figure 1.1).

Time	*Market requirement*	*Corporate management focus*	*Firm type*	*Management feature*
⬇	⬇	⬇	⬇	⬇
• 1960s–1970s	• Price	• Production efficiency (cost reduction)	• Efficient firm	• Fordism (standardization and mass production)
• 1980s	• Price + quality	• Efficiency + quality	• Quality firm	• Total quality management
• 1990s	• Price + quality + product line	• Efficiency + quality + flexibility	• Flexible firm	• Flexible manufacturing system; JIT (just in time)
• Late 1990s–present	• Price + quality + product line + uniqueness	• Efficiency + quality + flexibility + innovativeness	• Innovative firm	• Total innovation management

Figure 1.1 Evolution of corporate management

Source: Kumpe and Bolwijn (1994).

Increasingly shorter technology life cycle

Whereas it took typically several decades to successfully commercialize a technological invention in the first half of the 20th century, the cycle shortened significantly beginning in the second half. The telephone took as long as 60 years to enter 50 percent of American homes in the first half of the 20th century, but the Internet took only 5 years to enter most American homes. Corroborating the increasingly fast cycle, Moore's law observes that the storage capacity per unit area of a chip doubles every 18 months and that the bandwidth of a backbone network doubles every 6 months (see Table 1.3).

The life cycle of software products, measured in terms of the duration from introduction to exit or replacement by other products, has dropped to 4 to 12 months. Similarly, the time is 12 to 24 months for hardware and consumer electronics products, and 18 to 36 months for white goods. The firm is therefore compelled to adopt an innovation strategy. Without fast innovation, a firm would end up losing market share as its products become out of date.[4]

Towards an innovative firm

The Boston Consulting Group (BCG) issued The 50 Most Innovative Companies in December 2018, ranking Apple on top for one more year and including three Chinese companies[5] (see Table 1.4).

The companies on the list were generally believed to have four elements essential to success: high speed of innovation, good and simple R&D procedure, employment of a technology platform and systematic development of neighboring markets.

If we look back on the rankings over the past decade, we would find that many regular winners are masters of innovation, the power that drives continually growing proceeds. These include Apple, Google, Microsoft, Samsung, Tesla, BMW, Amazon, IBM, Hewlett-Packard, SpaceX, General Electric, Cisco, Huawei, Alibaba and Tencent.

Table 1.3 Significant technological innovations in history

Technology or product	*Year of invention*	*Year of innovation*	*Invention-innovation cycle (y)*
Fluorescent lamp	1859	1938	79
Compass	1852	1908	56
Zipper	1891	1918	27
Television	1919	1941	22
Jet engine	1929	1943	14
Copy machine	1937	1950	13
Steam engine	1764	1775	11
Turbine engine	1934	1944	10
Radiogram	1889	1897	8
Triode	1907	1914	7
DDT	1939	1942	3
Freon	1930	1931	1

Source: Qingrui (2000)

Table 1.4 The 50 most innovative companies for 2018

1. Apple	18. General Electric	35. Adidas
2. Google	19. Orange	36. BMW
3. Microsoft	20. Marriott	37. Nissan
4. Amazon	21. Siemens	38. Pfizer
5. Samsung	22. Unilever	39. Time Warner
6. Tesla	23. BASF	40. Renault
7. Facebook	24. Expedia	41. 3M
8. IBM	25. Johnson & Johnson	42. SAP
9. Uber	26. JPMorgan Chase	43. DuPont
10. Alibaba	27. Bayer	44. InterContinental Hotels Group
11. Airbnb	28. Dow Chemical	45. Disney
12. SpaceX	29. AT&T	46. Huawei
13. Netflix	30. Allianz	47. Procter & Gamble
14. Tencent	31. Intel	48. Verizon
15. Hewlett-Packard	32. NTT Docomo	49. Philips
16. Cisco Systems	33. Daimler	50. Nestle
17. Toyota	34. AXA	

Source: Michael Ringel and Hadi Zablit. Published online at January 17, 2018. www.bcg.com/en-us/publications/2018/most-innovative-companies-2018-innovation.aspx

According to the analysis of American scholars Kumpe and Piet, the mainstream model of corporate development has evolved from the effective firm to the quality firm, and then to the flexible firm; now the flexible firm is on the road to becoming the innovative firm (Kumpe and Bolwijn, 1994) (as shown in Figure 1.2). It's worth noting that Chinese firms are typically 10 to 20 years behind the international firms with regard to a development model due to historical reasons and technological strength.

The facts have shown that beginning in the 1990s (especially the 21st century), the majority of the most successful firms made it through cost reduction combined with quality and flexibility improvement. However, increasing economic globalization and competition have driven some firms to look beyond the relentless pursuit of quality and flexibility. They put a premium

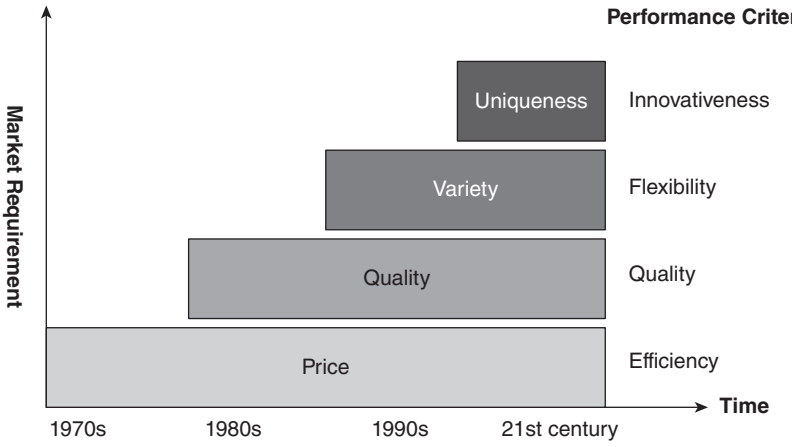

Figure 1.2 Evolution of the corporate development model

Source: Kumpe and Bolwijn (1994)

on innovation in order to compete with their rivals for market share as innovative organizations. Fast innovation has gradually emerged as a key weapon of market competitiveness as the one-time flexible firms find they are losing market share to more innovative firms. Of course, high efficiency, quality and flexibility remain the pillars of innovative firms.

Typically, an innovative firm makes a consistent effort to seek new breakthroughs in the area of its specialty to reduce cost, improve quality and flexibility and, finally, provide the market with products of outstanding price, quality and performance. The firm encourages an innovation culture and is equipped with an organizational structure and a stimulation mechanism conducive to effective communication and fast innovation (Greve, 2003).

The common belief of the innovative firms is that innovativeness has become the factor most critical to business success. An innovative organization is a learning organization as well. Innovation means not only the development of new products and technologies but also of new markets, of new material sources and of new uses for the same products (Schumpeter, 1934).

At present, most of the Chinese firms run in a model of efficiency and quality; a number of leading firms are characterized by flexibility; only a limited few of the leading firms have got on the road to innovativeness (Chen, Tong, and Ngai, 2007).

Overall, the innovative firm is a new type of firm as opposed to its counterparts focused on efficiency, quality and flexibility. Some prominent features of an innovative firm include the focus on such core values as innovativeness; the integration of global innovative resources (including the staff); a coordinated innovation model that covers tactics, strategy, culture, institutions, markets, organization and processes in a ubiquitous range; and self-developed IP assets and core technology needed to maintain a consistent competitive advantage.

The importance of innovation management

In *The Innovator's Solution* (Christensen and Raynor, 2013), Christensen writes:

> No matter how hard the gifted people are, many of the attempts to create new products have failed at last. 60% of the new products died before they are listed, and in the

> rest 40% of products that can be seen in the market, 40% of them are unprofitable and withdrawn from the market. In all, 75% of the investment in product development ended in failure at last.

The Department of Trade and Industry in the United Kingdom once conducted a survey of 14,000 organizations that purchased computer software and found that 80 to 90 percent of projects did not achieve the expected performance goals, about 80 percent of projects exceed the scheduled development time or budget, about 40 percent of projects end in failure and only 10 to 20 percent of projects achieved the expected goal successfully. In the process of innovation, various unknown factors are usually unpredictable. The results of innovation investment efforts are generally random, coupled with the uncertainty of the future market – thus, all of these make innovation a very risky business (Stirling, 2008).

Many innovative ideas are not able to be translated into new products. Also, many projects cannot become technically feasible products. And even if they are technically feasible, they may not necessarily get market recognition. The success rate of innovation in some industries is very low. Taking new drug development as an example, commonly, only 1 of 3,000 initial innovative ideas is able to be commercially successful. And it often takes 12 years or even longer from the discovery to listing of the new drug and costs hundreds of millions of dollars. Therefore, the innovation process is often seen as a funnel, and there are many new ideas with potential for development at the beginning, but only a few successes can be achieved in the end (see example in Figure 1.3).

In order to achieve better market success for innovation, Brem and Viardot (2015) underline the importance of the downstream activities of the innovation process, namely marketing and commercialization; they suggest adopting innovation as a priority in the innovation strategy of firms and governments, as the European Union has done in its Horizon 2020 innovation plan (Salmelin, 2013). Similarly, the importance of the adoption of innovation by consumers has been acknowledged with the emergence of the conceptual model of Quadruple Helix Innovation, where citizens are adding a fourth element to the more traditional combination of partnership for innovation between the industry, the government and the universities (Carayannis and Campbell, 2009).

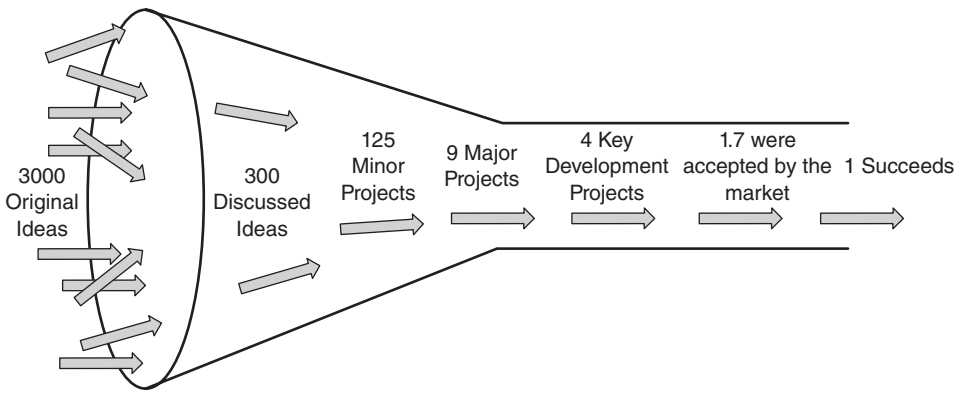

Figure 1.3 Sketch map of the innovation funnel model (using new drug development as an example)
Source: Jin (2002)

Innovation management: an integration framework

In order to complete the transformation of idea to market value, innovation management needs careful design in terms of strategy, organization, resource and culture (institution), which means the "creative destruction" based on deconstruction and the "organizational reconstruction and regularization" management activities based on construction are reasonably interacted to continuously promote the evolution of the company (Chen, Huang, and Xu, 2015). In general, innovation requires "horizontal-vertical theory", or in other words, a holistic innovation framework (Chen, Yin, and Mei, 2018). Horizontal management is the combination of vision and creativity, R&D, manufacturing and sales; vertical management requires the coordination of strategy, organization, resources and culture (institution) (see Figure 1.4).

Innovation strategy

Innovation requires the overall strategic guidance of the company. From the perspective of the logical structure and way of thinking of the discipline, innovation and strategy are almost the same. Or, at least, innovation should be taken into consideration when designing the corporate-level strategy. There is a strong correlation between the lack of indigenous innovation of Chinese companies and the weakness of their own strategic management capabilities, whereby indigenous innovation is a specific Chinese innovation term (Brem, 2009). Many companies only have profit and sales targets but no growth indicators based on indigenous intellectual property rights and technological innovation. Therefore, Chinese companies have always been unbalanced between their investment in growth (such as innovation) and their investment in shareholder or financial returns. There is no such strategic arrangement. A company that is eager to innovate must go beyond its traditional development model and realize the transformation from a business model based on introduction and simple manufacturing to the business model that integrates external emerging, breakthrough science technology and commercial resources to

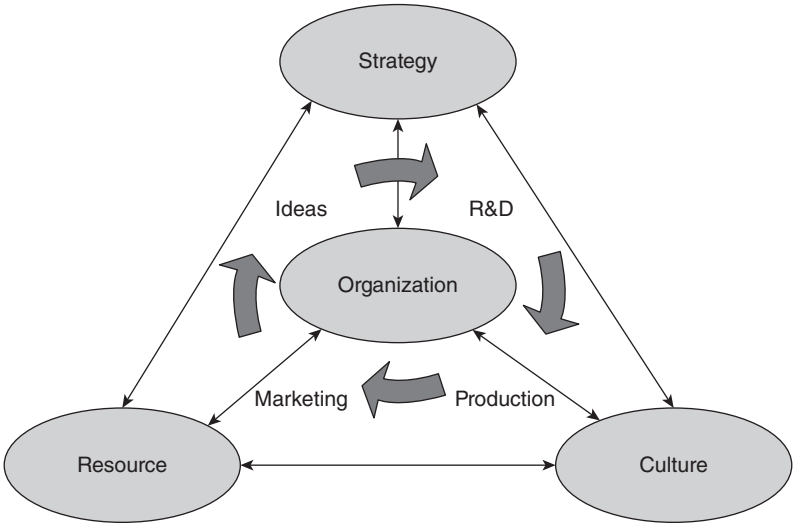

Figure 1.4 Holistic framework for corporation innovation management integration

Source: Chen (2002)

create higher value-added, more environmentally friendly products or services. In other words, companies that integrate innovation strategy, culture, resources and traditional strategic tools could achieve superior economic rents than the ones who don't (Chen, Huang, and Xu, 2015).

3M, the model of world-class innovation, has been strategically demanding that new products and services developed during the year should contribute 10 percent of the sales revenue for the next year, which makes 3M develop 1,500 new products each year. Some leading Chinese companies, such as China International Marine Containers (Group) Co., Ltd., have been transforming from the early stage of simply copying foreign samples to the development of high-quality products and strive to master the core patents, formulating or participating in the formulation of international standards for containers more actively, reflecting some Chinese enterprises' new understanding and actions in terms of innovation competition. Therefore, strengthening strategic management capabilities, enhancing strategic innovation capabilities and strengthening the benign interaction between corporate strategy and technological innovation are important conditions for the implementation of indigenous innovation. Without strategic analysis of corporate strategy, product design and technology realization, it is nearly impossible for Chinese companies to achieve indigenous innovation in a real sense.

Innovative organization

In order to realize indigenous innovation, a company should focus on optimizing the frame of innovative organization. Traditional Chinese companies continue the bureaucratic and hierarchical organizational structure of industrial society, which makes the connection between R&D, production and marketing very unstable. Even the high-intensity R&D is not enough to break the barriers (Baldwin and von Hippel, 2011). Besides, since market demand and technology supply cannot be matched appropriately, technological achievements are difficult to translate into new products and productivity. A modern innovative company must reform its organizational structure fundamentally and rebuild a customer-oriented and process-oriented organizational form, so as to translate ideas into products that are manufacturable and commercially valuable more quickly and efficiently.

The Haier Group constantly adjusts its organizational structure and strives to achieve a harmonious unity of business stream, product stream and logistics. This customer-oriented adaptive structure matches business orders with employees' work tasks, and even goes one step further in terms of the organizational structure that is visible and nonexecutive, or what we call it "flat organization" (Kanter and Dai, 2018; Lewin, Välikangas, and Chen, 2017). These actions played an important role in starting innovation and realizing the final value or innovation. The BMW Group is meticulous about its coordination of innovations. Every time BMW starts to develop a new type of car, 200 to 300 project team members from the engineering, design, production, marketing, procurement, and financing departments of the BMW Group will gather in the research and innovation center and work together for three years. This kind of close relationship can promote face-to-face communication, thus avoiding contradictions between marketing and engineering departments later on.

Companies should continue to strengthen organizational transforming in terms of innovation and build a superior process platform in order to turn new ideas into new values. The organizational structure is further oriented toward customers, flattening and reducing the bureaucratic control of the organization and enhancing the service function of the organization – it is a good method for the promotion of indigenous innovation of Chinese companies (Baldwin and von Hippel, 2011). In order to achieve this type of organizational transformation, future corporate managers should be led by the chief operating officer, chief innovation officer and chief

resource officer. The main responsibility of the chief executive officer is to exert the enthusiasm and creativity of these three managers. We believe that the value creation of a company will be completed by operations-related and innovation-related activities. Operations (which mainly includes current products, markets, manufacturing, logistics, etc.) are mainly responsible for the creation of corporate cash flow and profits, while innovation (with an emphasis on strategy, technology, future R&D and market development) focuses on gaining potential and more options for future sustainable development. In order to achieve the value creation, a company must build or acquire powerful resources and capabilities and conduct management and service work appropriately. What's more, the chief innovation officer needs to integrate the capabilities of marketing expert, technical expert, strategist and industrialist.

Innovation of resources

Resource refers to the core assets for a company to obtain a competitive advantage (Barney, 2001), while at the same time, innovation is a creative recombination of resources (Schumpeter, 1934). The resources include a series of tangible and intangible ones, such as information, capital, talent, brand and intellectual property (Barney, 2001). Realizing indigenous innovation of a company requires it to continuously enrich and expand its innovation resources, especially information and knowledge sources. In order to speed up this process, a company needs to fully mobilize the enthusiasm of employees to participate in innovation and gradually realize the full participation of the company's indigenous innovation (Xu et al., 2007). The Baosteel Group Corporation' requires four annual rationalization suggestions from each person, and more people are engaged in competitive information development every year, which is a valuable attempt among domestic companies in this regard. Toyota has become the most innovative company in the world, with 35 suggestions per person every year and a total of 2,000,000 suggestions, which helps Toyota generate continuous creative and valuable ideas that could be commercialized into profitable products.

The market research ability of Chinese companies is still weak. Regarding the condition that market demand is increasingly segmented, relying solely on operator intuition is not enough. Most Chinese companies still don't know how to apply the scenario analysis method yet. Technology foresight, competitive intelligence tools that should be used for the analysis of strategy and market or overall information and intelligence resources of enterprises are still scarce. Compared to all computer publications ordered by IBM and the knowledge library of Huawei, most of the files and information bases of Chinese companies still need to be improved.

In the open innovation era, companies cannot just rely on internal limited resources to achieve innovation (Chesbrough, Vanhaverbeke, and West, 2006). The ability of acquiring external knowledge becomes more and more important. Interactive learning is an important condition for acquiring external resources to create innovation (Berchicci, 2013). Therefore, learning and R&D will become two important aspects of innovation. At the same time, users, especially the leading users who are directly involved in innovation, will accelerate the process of innovation and increase the success rate (Foxall and Johnston, 1987; Brem, Bilgram, and Gutstein, 2018). We believe that user-based democratized innovation will have a great influence on China's innovation practice. Similarly, suppliers are also major innovators. For companies with strong capital capability, they can help small, technologically advanced companies develop innovative projects via seed funding and venture capital. In this way, big companies could obtain technological capabilities through the successful R&D of small companies, who are suppliers for them. In order to avoid duplication of R&D or to offset for deficiencies in the company's technology, companies can also acquire advanced technologies and key technologies efficiently

and economically through the purchase of external technologies or technology mergers to accelerate technological innovation.

In short, the process of diversification and integration of corporate innovation resources should also be part of the process of establishing a corporation innovation network. Innovation resources and innovation networks complement each other and jointly promote corporation innovation, in which efficient flow and recombination of resources through internal and external networks could accelerate the innovation and commercialization process.

Innovation culture

An innovation culture plays an important role in the effective development of technological innovation (Kratzer, Meissner, and Roud, 2017). Compared with information, capital and organizational structure, innovation culture is called the other side of technological innovation. The reason why the innovation of Haier succeeded is because it effectively integrates Confucian culture (a suitable hierarchy), American entrepreneurial spirit, Japanese team culture and German quality culture. Emphasis on innovation culture can have a greater significance. Zhang Ruimin defined himself as a chief cultural officer, which gave him a higher vision than the general CEO. Therefore, he further promoted Haier's innovation via pushing and building a culture that attracts full participation and encourages both exploitation and exploration.

Values, institutional systems, behavioral norms and physical carriers are the four aspects of innovation culture and must be highly emphasized by the top management team. Values are the basic characteristics of culture, and contemporary culture innovation should take entrepreneurship as the core and pursue a culture of advancement, development, change and excellence. Innovation culture determines the value orientation of technological innovation. The scale, level, focus and method of technological innovation are often determined by its value orientation. Sony Corporation has always taken "technical leading" as the fundamental orientation of its innovation culture, and its technological innovation is very active. 3M takes "proportion of new products/new business income to sales revenue" as the main goal of business operations, which made it one of the most successful innovation companies in the world.

In order to run the innovation culture, it must be based on a certain system. The communication system of technology and market and the management system of technical human resources are two systems related to technological innovation. The human resource (HR) systems in Chinese companies need revising. The HR system that truly suits innovation is flexible, whereas the hierarchical solidification makes people unwilling to change themselves. At Microsoft, employees are divided into 15 levels that vary from year to year, and salaries are set according to grade. Innovative companies often implement multihierarchy career systems, such as the 15 levels of Microsoft and the 27 levels of Haier.

A behavioral norm is the basic characteristic and specific appearance of culture (Greve, 2003). The innovation culture manifests itself in behavioral norms for entrepreneurs and corporate employees, and the key is to embrace innovation, understand innovation, participate in innovation, value innovation, tolerate failure and have respect for employees' backgrounds (nationality, regions, family, etc.).

The physical carrier is an objective symbol of innovation culture and has obvious guidance and demonstration effects. For example, many innovative companies strongly encourage the establishment of individualized offices, setting up clear signs for the most creative employees and constructing exhibition venues for innovative products for companies. These venues should be displayed to people inside and outside the company to establish the employees' sense of honor in the innovative products.

The best embodiment of a flexible culture of innovation is 3M, while the best embodiment of innovation and cultural discipline is some of China's outstanding companies. Companies such as Huawei and Haier have strict disciplines and even some militarized management styles. Disciplinary culture ensures that all kinds of resources are unimpeded and decisions are implemented.

In general, the culture of innovation should be a unique dualistic culture. On the basis of maintaining unity and coordination, appropriately increasing the connotation of individuality and tolerance for failure is the cultural foundation for companies to achieve indigenous innovation.

Notes

1 See also: www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies
2 See also: https://learn.rdmag.com/20180112_gff_2018_rd_lp
3 See also: www.bloomberg.com/news/articles/2018-01-22/south-korea-tops-global-innovation-ranking-again-as-u-s-falls
4 Schilling, Melissa A., *Strategic Management of Technological Innovation*. Translated by Xie Wei and Wang Yi. Tsinghua University Press, 2005.
5 See also: www.bcg.com/en-us/publications/2018/most-innovative-companies-2018-innovation.aspx

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