Evolving from traditional to sharing manufacturing business ecosystem through open innovation: Case study of Shenyang machine tool group

Accepted 25th March, 2020

ABSTRACT

Sharing manufacturing constitutes an important aspect of the supply-side sharing economy and is fundamentally changing the perspective of existing manufacturing industry to a more sustainable business ecosystem. Despite that sharing economy has been well established in existing literature with regard to demand or consumption-side models such as accommodation sharing, car sharing, and bike sharing, sharing manufacturing has been rather neglected. In particular, the evolution process from traditional to sharing manufacturing and the underlying dynamics have not been answered. To address this gap, we built our study on business ecosystem and open innovation theories and conducted a case study of Shenyang Machine Tool Group, a traditional machine tool company in China who has established a sharing manufacturing business ecosystem. This study shows that the evolution from traditional to sharing manufacturing business ecosystem experiences three sub-stages, including preparation, demonstration, and generalization, over which the business ecosystem’s value network transforms from supply-chain-based to cooperation-based then to platform-based while the embedded resources are enriched continuously. Moreover, the focal machine tool manufacturer can facilitate the evolution by adaptively conducting open innovation at different sub-stages. Our research broadens our knowledge on the process and dynamics of evolution from traditional to sharing manufacturing and contributes to business ecosystem theory.

Key words: Sharing manufacturing; business ecosystem; open innovation, case study.

INTRODUCTION

Sharing economy has been regarded as an important means of promoting sustainable development and a new megatrend (Martin, 2016). In addition to the new business models on demand side such as accommodation sharing (Airbnb), car sharing (Uber and Didi) and bike sharing (Mobike and OfO), sharing economy also drives the generation of sharing manufacturing on the supply side. Sharing manufacturing is a new networked manufacturing paradigm in which the pooling, sharing, and coordinating of distributed manufacturing resources and capabilities among different companies is enabled through the centralized management and intelligent control of sharing manufacturing platform (Becker and Stern, 2016; Kaihara et al., 2017; Bouzary et al., 2018). Sharing manufacturing empowers companies to better deal with market fluctuations or unforeseen disruptions, reduce safety or redundant capacity and increase efficiency (Tao et al., 2011; Becker and Stern, 2016; Rong et al., 2018a). Moreover, it
also fundamentally changes the perspective of existing manufacturing industry to a more sustainable, more interactive, and more service-oriented business ecosystem (Tao et al., 2011; Xu, 2012; Fisher et al., 2018). Nevertheless, the transition from traditional to sharing manufacturing business ecosystem would be a very complex and challenging process, during when a series of problems need to be addressed, such as the possible resistance from traditional entrenched manufacturing models, lack of standards and criteria to support free transaction and on-demand use of manufacturing resource and service, lack of reliable security technologies and solutions under the internet environment, etc (Tao et al., 2011). Especially for the incumbent focal and successful companies, adapting to and even pushing forward a disruptive innovation over their existing business model would be highly risky and challenging. Therefore, the evolution from traditional to sharing manufacturing business ecosystem and the strategies of incumbent focal firms represent very important research agendas.

Existing literature has hardly covered the above research agendas. For one thing, the main bulk of sharing economy literature has primarily focused on demand side sharing practices, lacking research on supply side sharing models such as sharing manufacturing (Becker and Stern, 2016; Rong et al., 2016). Only limited relevant studies have been conducted on sharing manufacturing, discussing the benefits and preconditions for horizontal alliances among manufacturing companies (Oum et al., 2004; Garrette et al., 2009), or focusing on information sharing among manufacturing companies but not explicit equipment or resource sharing in the manufacturing process (e.g., Hardwick et al., 1996; Young et al., 2007; Sandberg, 2007). According to our literature review, no study has been found in directly analyzing the emerging or evolution process of sharing manufacturing and its underlying dynamics. For another thing, although business ecosystem (BE) theory has become a valuable perspective widely adopted in sharing economy research (see for example, Parente et al., 2018; Ma et al., 2018; Boons and Bocken, 2018; Leung et al., 2019), it still has two major deficiencies as for the sharing manufacturing context. Firstly, existing BE evolution models much neglects the disruptive evolution from a specific type of BE to another type of BE. Researchers have described the lifecycle of BE as ‘birth-expansion-authorities-renewal’ (Moore, 1993; Moore, 1996) or ‘emerging-diversifying-conveying-consolidating-renewing’ (Rong and Shi, 2015). However, existing literature has not elaborated on the connection process between the renewal of old BE and the subsequent birth of new BE. As noted by Rong et al. (2015b), the detailed evolution activities between different life-cycle phases remains unclear. Secondly, knowledge regarding the focal firms’ strategies during BE evolution remains very limited. Focal firms would have wide-ranging effects on complementary firms in a business ecosystem (Garud and Kumaraswamy, 1993; Pierce et al., 2009). An important BE nurturing strategy for focal firms that has been recognized is open innovation (Rong et al., 2010; Rong and Shi, 2015), which facilitates use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively (Chesbrough, 2007, 2011). Open innovation includes three paradigms, that is, inbound, outbound, and coupled open innovation (Enkel et al., 2009; Huizhong, 2011). However, few studies have investigated how focal firms should select and conduct open innovation at different stages of BE evolution. Rong et al. (2018b) argued that ecosystem studies should pay more attention to the source of innovation.

This study aims to unveil the dynamics of evolution from traditional manufacturing business ecosystem (TMBE) to sharing manufacturing business ecosystem (SMBE). Based upon business ecosystem and open innovation theories, we attempt to obtain answers to the following two research questions: (1) How does TMBE, a non-interacting and linear business model in which companies maintains exclusive manufacturing resources for their own use, evolve to SMBE step by step? (2) How do incumbent focal firms in TMBE adapt themselves to and even facilitate such evolution? To do so, we conducted a case study of Shenyang Machine Tool Group (SYMGM), a leading machine tool manufacturer (MTM) in China and has successfully established a SMBE. Currently, SYMGM’s SMBE has incorporated various stakeholders including raw material and component suppliers, MTM, original equipment manufacturers (OEMs), business/consumer end users, financial institutions, real estate companies, local governments, etc. Over 25 thousand intelligent machine tools are connected to, dispersed in thousands of OEM factories around China. Our research on this unique case provides empirical evidence on the evolution process from TMBE to SMBE and how MTM, an important sort of focal incumbent firms in TMBE, dominated this evolution by conducting open innovation at different stages.

The remainder of the study is organized as follows: literature on sharing manufacturing, business ecosystem and open innovation, which form the basis of our case analysis; the methodology in our study; the research findings and supporting evidences; and finally, conclusion by presenting the theoretical and practical implications of our research, as well as limitations and future directions.

THEORETICAL BACKGROUND

Traditional and sharing manufacturing from business ecosystem perspective

A BE is defined as a loosely connected business community in which a variety of inter-related stakeholders co-evolve to renew themselves, and stimulate collaborative innovation (Moore, 1993, 1996; Iansiti and Levien, 2004; Liu and Rong,
Firms in a BE can expand their view beyond their supply chain partners to include some other non-direct business partners, such as industry associations, government agencies, etc (Anggraeni et al., 2007; Liu and Rong, 2015). The manufacturing industry can be considered a BE as it incorporates multiple interconnected stakeholders that coexist and interact in a dynamic environment and codetermine development of sharing manufacturing. As such, the BE approach offers a promising theoretical lens for our study. Specifically, we define two sorts of manufacturing business ecosystem as follows, including traditional manufacturing business ecosystem (TMBE) and sharing manufacturing business ecosystem (SMBE).

A TMBE is a set of stakeholders such as raw material and component suppliers, machine tool manufacturers (MTMs), original equipment manufacturers (OEMs), and business/consumer customers that follow specific guidelines and tiered structure of control to supply intermediate or final products to downstream market to create value (Wu et al., 2013; Gawer and Cusumano, 2014). TMBE is based on the traditional production-oriented supply chain and focuses on improving production efficiency, information flow and financial flow (Martinsons, 2008; Fisher et al., 2018). This results in rather stereotyped revenue models, separating the value adders from each other and defining their compensations based on the value they can add to the product (Wu et al., 2013). Besides, in order to lower production time and cost and improve machining quality (Wang, 2013), all resources are assumed to be centralized in the same geographical position, leading to low utilization efficiency (Wang et al., 2017; Li et al., 2018). However, the old hierarchical ways of organizing work and innovation do not afford the level of agility, creativity, and connectivity that companies require to remain competitive in today’s environment (Tapscott and Williams, 2006).

SMBE refers to the community in which the inter-related stakeholders such as raw material and component suppliers, MTMs, OEMs, customers, governments, financial institutions, etc., that interact and co-evolve with the primary goal of enabling shared access and coordination of distributed manufacturing resources. In SMBE, the previously parallel stakeholders are organized and connected through the sharing manufacturing platform (Kaibara et al., 2017; Bouzary et al., 2018), which is identified as a key way to deal with the dynamic environment and facilitate the development of BE (Moore, 2006; Rong et al., 2013). The sharing manufacturing platform utilizes advanced technologies such as internet of things (IoT), cloud computing, and virtualization to package and coordinate manufacturing resources and capabilities as services on a pay-as-you-go scheme (Tao et al., 2011; Xu, 2012; Fisher et al., 2018). The platform is provided as a service (PaaS), which can enable the development and deployment of applications without the complexity and cost of buying and managing the required hardware and software, leading to flexible usage of globally distributed manufacturing resources (Adamson et al., 2017).

The configuration of TMBE and SMBE are shown in Figure 1.

**Figure 1**: Comparison between TMBE (left) and SMBE (right).

**Dynamics of business ecosystem evolution**

A BE can be analyzed in two perspectives: 1) the constitutive elements, including value network and embedded resource; 2) the interactive mechanisms, including industrial transformation and industrial feedback (Ma et al., 2018; Rong et al., 2018b). These constructs act as
the theoretical basis for analyzing the dynamics of BE evolution, as shown in Figure 2.

The configuration of a BE can be decomposed into two elements, the value network and the embedded resource, which need to exist simultaneously to produce a stable business environment (Ma et al., 2018; Rong et al., 2018b).

On one hand, the value network is the industrial system that engages the stakeholders and hosts their entrepreneurship and networking activities, enabling BE as a kind of habitat for productive interactions (Ma et al., 2018). The value network may take many forms, such as a supply chain (Moore, 1996) or a platform (Gawer and Cusumano, 2014). On the other hand, the embedded resource includes the physical, financial, human, social, cultural, or political capitals, which may not involve in the existing value network but could be potential contributors. The embedded resource may be possessed or accessed by a variety of stakeholders in addition to the core businesses, such as governments, industrial associations, financial institutions, local communities (Moore, 1996; Parente et al., 2018; Ma et al., 2018; Rong et al., 2018b), etc.

From the dynamic view, the innovation and evolution of a BE is realized based upon the interaction mechanisms between value network and resource pool (Wareham et al., 2014; Liu and Rong, 2015; Rong et al., 2015a), which include two components. Firstly, industrial transformation is the process in which the embedded resources are mobilized by the ecosystem’s focal firms and transformed into a connected value chain or platform and renew the existing ones (Shi and Shi, 2017). Vision sharing is an example of industrial transformation mechanism, which allows stakeholders to hold a shared picture of the future, combine their efforts, and work together in an innovation project, forming an important part of co-evolution (Harvey Jones, 1998; Hodgkinson, 2002; Liu and Rong, 2015). Secondly, industrial feedback allows the value network to enrich, renew, and nurture the embedded resources (Ma et al., 2018). As the value network grows, a larger number and range of stakeholders would accumulate, bringing access to resources that would otherwise lack.

**Business ecosystem focal firms and their open innovation**

Focal firms are central players in an ecosystem that control the technological architecture or brand that drives value in the ecosystem (Pierce, 2009). These enterprises serve to coordinate suppliers and complementors through compatibility and direct network management (Albornoz and Yoguel, 2004; Pierce, 2009). Therefore, focal firms’ actions and strategies would have wide-ranging effects on the entire ecosystem (Garud and Kumaraswamy, 1993; Pierce, 2009). Gawer and Cusumano (2014) indicated that focal firms need to develop the shared vision and promote this among potentially key players in the present and the future, build a sufficiently open architecture to facilitate innovation, and manage ecosystem relationships that are mutually beneficial for participants. Despite its necessity, the existing literature still lacks empirical research that incorporates the focal firm’s strategy into the analysis of BE evolution dynamics. There are still questions to be answered such as how the focal firms can explore the embedded resources to sustainably maintain the ecosystem (industrial transformation) or take advantage of network effect to enrich embedded resources (industrial feedback) (Rong et al., 2018b).

Nevertheless, several authors have proposed open innovation as an important BE nurturing strategy for focal firms (Rong et al., 2010; Rong and Shi, 2015). Open innovation is defined as ‘the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively’ (Chesbrough, 2006). It describes the innovation processes in which firms get access to external knowledge exploration and exploitation through interaction with their environment. Open innovation is important for focal firms to nurture business ecosystem

---

**Figure 2:** Dynamic BE framework (Rong et al., 2018b).

---

- **Value network**
- **Industrial transformation**
- **Embedded resource**
- **Industrial feedback**
because it aims at leveraging resources to improve both central firm performance and partners' innovation performance (Rong et al., 2015b). Specifically, open innovation encourages user innovation, lead market and open source (Rong et al., 2010), which will encourage the partner stakeholders to develop product based on the focal firm’s platform. The focal firms themselves will also create value by accumulating more and more suppliers, customers, and other stakeholders in the age of platform-based business (Armstrong, 2006). Open innovation results in focal firm's co-creation with complementary partners, such as communities, consumers, universities, etc., through alliances, cooperation, and joint ventures (Hienerth, 2006; Enkel et al., 2009), which is recognized as a focal part of BE co-evolution (Liu and Rong, 2015).

Open innovation can be differentiated as three paradigms based on the direction of knowledge flow (Enkel et al., 2009; Huizingh, 2011): (1) Inbound open innovation: it is related to the process which firms make greater use of external ideas and technologies in their own business (Chesbrough, 2011); (2) Outbound open innovation: it refers to the process which firms allow its own technologies, ideas or knowledge to be utilized by external businesses (Chesbrough, 2011); (3) Coupled open innovation: it refers to process which firms combine the outside-in process (gaining external knowledge) and the inside-out process (making internal knowledge to be externalized) (Enkel et al., 2009). An increasing number of researchers have become interested in studying firms' open innovation from the perspective of aforementioned three open innovation processes (Henkel, 2006; Chesbrough, 2007; Lichtenhaler and Frishamar, 2011; Spithoven et al., 2013).

Analytical framework

In summary, we propose the analytical framework based on two building blocks, business ecosystem and open innovation theories in order to explore the evolution process from TMBE to SMEB. Specifically, a BE not only includes value network and embedded resource as constitutive elements, but also features the interactive mechanisms, industrial transformation and industrial feedback, as the underlying dynamics for BE evolution. Additionally, focal firms may facilitate these mechanisms through properly conducting three sorts of open innovation, i.e. inbound, outbound, and coupled open innovation. The framework is summarized in Figure 3.

METHODOLOGY

Research design

In consideration of the unique characteristics in the complexities of evolution process from TMBE to SMBE, a qualitative case study research design was chosen since it contributes to the generation of new management theories by providing insights from detailed and dynamic case scenarios (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 1994). Our case is the manufacturing business ecosystem around the focal firm SYMG, the leading Chinese MTM. Specifically, we focus our analysis on its evolution from TMBE to SMBE, and explore how SYMG facilitates such evolution through open innovation strategies. The reasons are as follows: Firstly, SYMG has successfully established a SMBE and mobilized different stakeholders including component suppliers, OEMs, end users, financial institutions, governments, and others to join. In the SMBE, the machine tool operators follow a business model of pay-for-use rather than pay-for-possess. A cloud manufacturing platform namely iSESOL has gone online since 2016, connecting more than 25 thousand intelligent machine tools from OEM factories around China by the end of 2018. Secondly, SYMG is a pioneer and typical enterprise for successful implementation of open innovation in the machine tool industry of China. SYMG's open innovation not only involved its suppliers, competitors and customers in its original supply chain, but also covered companies from internet, finance, real estate, electronics, and jewelry industries. The company’s series of explorations under the open innovation model contributes to our understanding of how traditional manufacturing enterprises conduct open innovation strategies. Thirdly, many scholars have argued that ecosystem research has not been adequately conducted in the context of non-Western countries (Rong et al., 2018b; Meng et al., 2018). By setting our research context in SYMG, the leading MTM in China, the present study may enrich the current research by analysing the key process of business ecosystem renewal in the Chinese context.

For its success with regard to nurturing SMBE and open innovation, SYMG provides us with a unique case to learn about the evolution process from TMBE to SMBE and MTM’s roles. Researching a case such as this allows us to formulate propositions and create theoretical concepts using empirical evidence even from a single case (Bank et al., 2017; Eisenhardt, 1989; Flyvbjerg, 2006). Despite the potential shortcomings of a single case study, this methodological approach is common and important in social science studies (Flyvbjerg, 2006). Furthermore, our analysis of SYMG is based on a dynamic process lasting 12 years, including three substages of 'preparation', 'demonstration' and 'generalization', as illustrated below.

By comparing and synthesizing findings from these three stages, the results and methods are more persuasive and more rigorous (Eisenhardt, 1989).

Data collection

We relied on diverse sources of data to conduct cross-validation and obtain detailed information (Eisenhardt,
First-hand data were gathered from semi-structured interviews with three senior staff of SYMG, including two from the i5 machine tool R&D team and one from the strategy department. The interviewees knew very well about the evolution of SYMG's technology, business model and strategy of the past years. Our interviews were conducted during August, 2018 and September, 2018, each time lasting between 30 to 45 minutes. We followed predesigned interview protocols and asked each interviewee about their specific jobs and responsibilities, the development process and milestones of SYMG since 2000, how SYMG's sharing manufacturing works, how SYMG cooperated and interacted with other stakeholders, and how such interaction has helped in nurturing SMBE. By cross-asking similar questions with different respondents, the information gleaned was repetitively verified, which helps to reduce potential bias resulting from impression management and increases research validity (Eisenhardt and Graebner, 2007). Moreover, we searched secondary data from a wide array of sources in order to confirm and supplement the information acquired from primary interviews (Yin, 1994), as showed in Table 1. For example, we searched for SYMG's official introductory materials from its annual reports and official websites. We gathered information about SYMG's important events from news media and search engines. The patent portfolio of SYMG was also searched through State Intellectual Property Office of China, which provided valuable materials for us to understand the unique attributes of SYMG's intelligent machine tool products. Lastly, we also gathered the academic papers which also took SYMG as cases to supplement our case data.

Data analysis

The collected first-hand and secondary data were interpreted, refined, and tested along with the perspectives derived from existing research, leading to the generation of grounded theoretical findings on business ecosystem transformation alongside open innovation (Glaser and Strauss, 1967; Langley, 1999). All interview and secondary data were transcribed into a database. The analysis of the database was conducted in three interactive and iterative steps, which were in line with our research questions. Firstly, SYMG’s open innovation practices were identified, with specific attention to who the open innovation partners were and the direction of knowledge flow. Secondly, we further identified the evidence which reflected the condition or evolution of BE elements, namely value network and embedded resource. Thirdly, we presented the evidences in chronological order and divided the overall process into different substages based on the developed conceptions. We continuously revisited our data as insights about BE evolution and focal firm’s open innovation strategies emerged but leaving further analysis until we had finished the write-ups.

Our case analysis showed that the evolution from TMBE to SMBE was a three-stage process: (i) preparation stage (2007-2012), when the value network remained supply chain-based but the embedded resource became richer; (ii) demonstration stage (2013-2015), when the value network evolved from supply chain-based to cooperation-based and the embedded resource became richer; (iii) generalization stage (2016-2018), when the value network evolved from cooperation-based to platform-based. The division of the business ecosystem evolution process is based on intra-phase differences in terms of BE elements (value network and embedded resource) and SYMG's open innovation. In order to present the sequence of major events in our longitudinal cases, as well as better understand the process of business ecosystem evolution, we present the research findings phase by phase in the next section.

RESULTS

Preparation stage (2007-2012)

At the beginning of 21 century, the heavy industry in China
to take off, and SYMG’s sales revenue rose rapidly. However, at that time, SYMG was merely able to engage in R&D and production with regard to ordinary non-numerical control machine tools. SYMG’s machine tools could be only used in small batch production of parts with simple outline, low accuracy requirement and small process size. SYMG had no technological basis in the field of high-end computer numerical control (CNC) machine tools. Managers of SYMG thought that the lack of CNC technology will restrict the development of SYMG in the long term. SYMG decided to put efforts in the research of CNC machine tools since 2007.

Due to the lack of prior knowledge base, SYMG engaged in inbound open innovation, mainly reflected in two aspects. Firstly, SYMG learnt and hired technical talents from universities and research institutions. In 2007, there were few talents with CNC machine tool development experience in China, except for some university teams that had done basic research on CNC machine tools. Therefore, SYMG cooperated with top domestic universities and research institutions such as Tongji University (TJU), Beihang University (BHU), and Chinese Academy of Sciences (CAS) to establish joint R&D teams. Some technical personnel from universities even chose to join SYMG to devote to the localization of CNC machine tools. For example, Zhihao Zhu, the former professor of TJU, was persuaded to join SYMG by Xiyou Guan, the general manager of SYMG. Zhu served as the principal of CNC machine tool R&D team of SYMG. Secondly, SYMG learnt CNC technologies from various leading international machine tool enterprises. In 2007, SYMG selected 50 engineers and sent them to Germany to go to Siemens and R+P Machine Design Institute to be trained and jointly develop gantry five-axis machining center, high-speed horizontal machining center, and other high-end CNC machine tools, totaling 13 series. Besides, SYMG also cooperated with FIDIA, a professional CNC system company in Italy, in order to learn about FIDIA’s CNC platform and conduct secondary development. From 2007 to 2012, SYMG invested nearly 1.2 billion RMB in CNC technology R&D and reached yearly R&D intensity of about 2%, which increased significantly as compared with before 2007.

In 2012, SYMG successfully developed the i5 CNC system with intelligent and interconnected functions (i5 stands for industrialization, information, internet, intelligence and integration). From 2007 to 2012, SYMG updated 1917 versions of its CNC system, accumulated 1032 test cases and nearly one million lines of code, obtained 23 patents and 17 software copyrights. More importantly, the i5 system which was developed based on extensive cooperation followed differentiated technology route compare with traditional CNC systems. While traditional CNC system is a specialized, embedded, and closed system with its hardware and software highly coupled with each other, the i5 system applies the architecture similar to personal computers (PCs) and realizes the decoupling of software and hardware. This innovative feature not only reduced the difficulty of software development, but also adapted to the future of a more intelligent, modular and reconfigurable manufacturing industry. As noted by Guan, the general manager of SYMG:

‘We chose PC architecture because we were forced to...As a result of underdeveloped software technologies in early years, all the machine tool manufacturers around the world have followed the route of industrial controller. We can never surpass the incumbent leaders on the traditional scheme.’

Yunying Huang, the vice director of SYMG Shanghai R&D center, indicated the difference between i5 and traditional CNC systems:

‘Traditional CNC system was developed under “the times of DOS”, which was relatively closed and not
internet-oriented... However, i5 system applies PC architecture and naturally has the property of communication and connection. Therefore, we did a lot of things in addition to motion control, that is making the machine tool easier to use for its operators by taking the advantage of software.’

In conclusion, inbound open innovation of SYMG drove the BE to realize industrial feedback, helping SYMG and partners to jointly develop new CNC technologies, that is, enriching embedded resources in the BE. Figure 4 shows the analysis process and the case elements that underpin the conception development of phase one. We label the first stage of evolution from TMBE to SMBE as ‘preparation’ and suggest the following proposition:

Proposition 1: During the preparation stage, MTM conducts inbound open innovation to facilitate industrial feedback, enriching the embedded resource.

Demonstration stage (2013-2015)

After a decade of rapid growth, China’s machine tool industry experienced severe demand shrinks in 2012. Compared with 2011, SYMG’s machine tool sales dropped by 34% and the revenue dropped by 19%. Meanwhile, organized by the German government, Siemens and other German companies and research institutes jointly proposed the ‘Industry 4.0’ initiative, which was officially launched in April 2013 as Germany’s national strategy. Under such circumstance, SYMG began its strategic transformation from industrial manufacturers to industrial service providers in 2013.

During 2013 to 2015, SYMG had adopted various measures to support its reform, mainly including three aspects. 1) SYMG established a cross-functional group to promote the commercialization of i5 series of machine tools. The team was led by Xiyou Guan and aimed to break the barriers of communication and coordination between different departments and make i5 machine tools to be recognized by the market. 2) SYMG setup market service department in its R&D institute, encouraging technical staff to go on business trips and talk to customers face to face. 3) SYMG also established Shanghai Younis Industrial Equipment Sales limited company in order to promote 4S shop marketing model. The above-mentioned measures significantly strengthened the interaction between SYMG and the market, and thus realized coupled open innovation between SYMG’s R&D department and the market. On the one hand, SYMG widely carried out promotion and trial of the i5 series of machine tools, allowing the market to gradually understand and accept its unique advantages and values. On the other hand, SYMG valued each opportunity to gather opinions from customers, based on which its products and services were further improved. As noted by Huang:

‘Our CNC system aims at the customer’s differentiated needs and is developed in the direction of intelligence. The customer’s feelings and experience are our focuses. The configuration...
of our institutions should definitely be market-oriented.'

Zhu, head of R&D team of i5 system, indicated:

‘Before 2013, I only need to focus on the process of R&D projects and instil my experiences to our team. Now, in addition to pushing forward the original projects, we have to deal with challenges from the market side simultaneously.’

SYMГ developed new business models through coupled open innovation. For one thing, SYMG began to provide full life cycle machine tool services rather than only selling machine tools. In the process of machine tool usage, SYMG could track and analyze the use of machine tool parts based on the monitoring and communication functions of the i5 system. Based on that, SYMG could estimate the life expectancy and the risk of failure of the machine tools and provide precise solutions for spare parts. When the machine tool reached the end of life, SYMG’s remanufacturing division would provide repurchase and renovation services, turning the waste into treasure. Meanwhile, the transaction mode between SYMG, customers and suppliers also changed. Financing lease was offered the customers by SYMG. Customers pay for the use of machine tools (but not possession) based on the machine tool running time, machining work amount and depreciation of parts. The payment would be shared by SYMG and upstream raw material and component suppliers. From the perspective of BE, the above-mentioned change can be interpreted as industrial transformation, leading to the value network to evolve from the traditional linear supply-chain to intensive cooperation and integration among suppliers, MTM and OEM.

Coupled open innovation of SYMG also brought about industrial feedback, which further enriched the embedded resources. In terms of resource quality, new functions and new technologies had been developed based on i5 machine tools. One example was the workshop information system (WIS), based on which the customers could schedule and arrange production through their mobile phones and view the production status in real time. SYMG also launched the intelligent computer cided manufacturing (iCAM) in the i5 system, which achieved on-line designing of personalized products and automatic generation of machining program. WIS and iCAM were totally free for users of i5 machine tools. In terms of resource quantity, sales of i5 machine tools increased quickly. In 2015, the shipment of i5 machine tools reached nearly 5,000 units, and repetitive purchase rate exceeded 50%. Better yet, SYMG’s new business model enabled many small OEM customers to use i5 machine tools. For instance, Yiqun Rong, the general manager of Hongyun Appliance Company in Cixi, Zhejiang, ordered 50 units of i5 machine tools in three months because of the ‘half-price repurchase in five years’ policy.

We identify the second stage of the evolution from TMBE to SMBE as demonstration’ stage. Figure 5 shows the
analysis process and the case elements that underpin the conception development of phase two. In all, we suggest the following proposition.

Proposition 2: During demonstration stage, MTM conducts coupled open innovation to facilitate industrial transformation and industrial feedback, which transforms the value network from supply chain based to cooperation based and further enriches the embedded resource.

Generalization stage (2016-2018)

The preliminary success in promotion of i5 machine tools and business model transformation had brought great confidence to SYMG. In 2015, Chinese government introduced various guidance policy documents for the manufacturing industry, such as ‘Made in China 2025’ and ‘Internet+’. Under such background, SYMG accelerated its strategic transformation, further promoted the intelligentization of machine tools and the diversification of industrial services.

In this period, SYMG focused on strengthening the interactions with companies from internet, finance, real estate and other industries to realize resource complementation, mutual learning and jointly exploring new business models, which can be categorized as coupled open innovation. For example, SYMG, Digital China (an internet company) and Everbright Financial Holdings Asset Management Co., Ltd together set up setup Intelligence Could Science Co., Ltd which faced Industry 4.0 and cloud manufacturing. SYMG also established strategic cooperation with Tencent Cloud Computing (Beijing) Co., Ltd to take full advantages of both parties and jointly create industrial cloud platform. Besides, in order to promote application of financial leasing of i5 intelligent machine tools, SYMG signed cooperative agreements with Zhongrongda Capital Investment Management Co., Ltd and China Development Bank Leasing Co., Ltd. SYMG also collaborated with China Fortune Land Development Co., Ltd to build new intelligent manufacturing industrial cities. SYMG also kept close communication with OEM customers, actively promoted and optimized i5 system and business model to various industries. Moreover, SYMG successively added business divisions such as electronics, jewellery, aerospace and so on, which aimed to provide customers in these industries with personalized solutions in the ‘industry 4.0’ era.

Industrial transformation in BE was promoted by coupled open innovation between SYMG and other stakeholders, bringing further evolution in value network. This can be manifested in three aspects: 1) iSESOL industrial cloud platform, developed by SYMG, Digital China and Everbright Financial Holdings Asset Management Co., Ltd, was launched in April, 2016. On iSESOL, while OEM factories with spare capacity can release the information about the model and quantity of their own machine tools, process level, factory address, qualification, etc, downstream business or consumer customers may publish machining drawings, quantity, delivery time, and other requirements. Therefore, iSESOL acted as a sharing manufacturing platform for OEMs and downstream customers to communicate and trade, that matching supply and demand. 2) SYMG integrated its i5 intelligent machine tools, WIS, and ‘pay-for-use’ model to develop intelligent factory solutions, offering full life cycle service including overall program design, equipment assembly and commissioning, and equipment tracking and order recommendations. 3) Through cooperation with local governments and industrial funds, SYMG launched a higher form of overall intelligent manufacturing solution ‘5D intelligent manufacturing valley’ in 2017, in which government provided land and policy supports, sector funds provided financial services and SYMG provided manufacturing equipment, service and orders, realizing joint investment attraction and reinforce complementary advantages. Zhixin Ju, director of SYMG intelligent manufacturing exploration center, noted:

‘5D manufacturing valley offers small and start-up firms a ‘safe entrepreneurship’ mode. In 5D manufacturing valley, you don’t need to worry about land, materials, equipment, and even market, all you need is to come with your ideas and products.’

Shengweiyi Intelligent Manufacturing Co., located in Shiyan, Hubei, is one of the earliest intelligent factories, which was a small company with 10 workers operating in three shifts and 9 i5 machine tools working 24 h a day. Jianwei Zheng, the general manager, noted:

‘Sometimes there are too many orders that we can hardly complete. So, I just share them with other small firms to work and make money together.’

The coupled open innovation also led to industrial feedback and enriched embedded resources. More and more OEMs have joined SYMG’s SMBE since 2016. As of the end of 2017, a total of 74 intelligent factory agreements were signed, of which 34 were launched; 22 thousand units of i5 machine tools had been in operation, half of which were connected to iSESOL platform. As of June, 2018, the amount of signed 5D manufacturing valley projects reached 12, covering various provinces such as Jiangsu, Zhejiang, Hubei, Anhui, Shandong, Hebei, Liaoning, etc. SYMG’s SMBE also attracted famous upstream suppliers to join and take the ‘pay-for-use’ model, such as Schaeffler (world famous supplier of driving system parts) and Exxon Mobil (world famous supplier of lubricating oil). Besides, the OEMs that traditionally only bought machine tools from foreign companies began to accept i5 machine tools, such as those produced consumer electronics, aerospace, jewellery, and
medical equipment. Two leading electronics OEMs, who provided cell phone shell parts to Huawei and Xiaomi, broke the rule of only purchasing imported machine tools and respectively signed an agreement with SYMG involving 5,000 units of i5M1.4 machine tools in 2016. The leader of one of the firms noted:

‘The accuracy and efficiency of i5 machine tools can absolutely satisfy our needs. Besides, its new business model of financial leasing has led the market trend. Taken together, i5 is the best choice for us.’

In 2017, SYMG provided an automatic ring assembly line for the famous jeweller Zhoudafa, which was also the first domestic produced automatic jewellery assembly line. Meanwhile, i5 machine tools were further classified into 6 series and 20 sub-groups, thereby increasing production quality and efficiency. WIS was upgraded to be compatible with competitor’s CNC system such as Siemens and Fanuc.

We label the third stage of evolution from TMBE to SMBE as ‘generalization’ stage. Figure 6 shows the analysis process and the case elements that underpin the conception development of phase one. In all, we suggest the following proposition.

**Proposition 3:** During generalization stage, MTM conducts coupled open innovation to facilitate industrial transformation and industrial feedback, which transforms the value network from cooperation-based to platform-based and further enriches the embedded resource.

**DISCUSSION**

This study sets out the task of unveiling the evolution process from TMBE to SMBE and the role and strategies of the incumbent MTMs. Based on analysis of SYMG in China, our research has established an integrative framework to analyze the process and dynamics of evolution from TMBE.
to SMEB and uncovered the relationship between BE’s constitutive elements, evolution mechanisms and MTM’s open innovation. Our conclusions can be summarized as the following three points: Firstly, the evolution from TMBE to SMEB includes three sub-stages, namely preparation, demonstration and generalization, over which the BE’s value network transforms from supply-chain-based to cooperation-based then to platform based while the embedded resources is enriched continuously. Secondly, by driving the interactive mechanisms within BE, that is, industrial transformation and industrial feedback, the focal MTM’s open innovation is a crucial strategy for the evolution from TMBE to SMEB. Thirdly, the focal MTM conducts different forms of open innovation at different evolution stages, namely inbound open innovation at preparation stage and coupled open innovation at demonstration and generalization stages. These findings are summarized in Figure 7.

**Theoretical contributions**

This study fills some major gaps in sharing manufacturing research. Sharing economy has become a popular term and received much attention from academic research (Belk, 2014; Parentre et al., 2018). While most existing studies focused on demand or consumption side sharing practices such as bike sharing (Mobike and Ofo) (Ma et al., 2018), car sharing (Uber and Didi) (Parentre et al., 2018) and accommodation sharing (Airbnb) (Zervas et al., 2017), sharing economy on supply side, including sharing manufacturing is yet to be properly explored (Rong et al., 2018). In particular, the evolution from traditional to sharing manufacturing and the underlying dynamics are still to be studied. In this study, we constructed a systematic framework based on BE and open innovation theories and applied it to the case study of SYMG, the leading Chinese MTM who has successfully transformed its BE from traditional to sharing manufacturing. Our research unveils the evolution from TMBE to SMEB as a process consisting of three sub-stages, namely preparation, demonstration and generalization, with the BE’s value network transforming from supply-chain-based to cooperation-based then to platform based and the embedded resources being enriched. Moreover, the focal MTM can facilitate the evolution from TMBE to SMEB by adaptively conducting open innovation at different sub-stages, including inbound open innovation at preparation stage and coupled open innovation at demonstration and generalization stages.

Our study also contributes to BE theory in three ways: Firstly, although BE scholars have proposed several multi-phase models to depict the lifecycle of BEs (e.g. Moore, 1996; Rong and Shi, 2015), there still dearth of research on the activities that promote the transition of one stage to another (Rong et al., 2015b), especially regarding the disruptive transformation from the renewal to the birth of a new BE. Our study remedies this deficiency by dividing the evolution process from TMBE to SMEB into three sub stages according to the change of two BE constitutive elements, value network and embedded resources (Shi and Shi, 2017; Ma et al., 2018; Rong et al., 2018b). Moreover, the
interaction mechanisms between these elements also functions differently at different stages. Secondly, knowledge regarding the BE stakeholders’ role during BE evolution remains very limited, leaving a gap between BE open innovation to the underlying dynamics of BE evolution and investigated how focal firms should select open innovation at different stages of BE evolution. The present study finds that open innovation nurtures BE development through its impact on industrial transformation and industrial feedback. MTM may take inbound open innovation in preparation stage and coupled innovation in demonstration and generalization stages. By focusing on the co-evolution of BE and focal firm’s open innovation, we established connection between two research streams, thereby addressed the above issues. Thirdly, the main bulk of BE studies have focused on Western ecosystem leaders (Rong et al., 2018b; Jacobides et al., 2018). BE in non-Western contexts have not gained equal attention, despite the well-known difference between Western and Eastern business societies (Rong et al., 2018b; Meng et al., 2018) and the fact that some leading Asian firms have developed ecosystem-leading positions. This study focuses on SYMG, which is a leading MTM in China and has successfully established a SMBE out of its original supply chain. It highlights the important role of MTM’s open innovation in driving the evolution from TMBE to SMBE. By analyzing the case of SYMG, we enriched BE studies by extending to Chinese context.

Practical implications

Our research offers threefold practical implications. Firstly, this study offers an overall picture of evolution process from TMBE to SMBE to policy-makers, firms, and other institutions in countries or regions that are actively promoting the development of sharing manufacturing. As the above analysis indicates, the transition from TMBE to SMBE would experience a long term and complex process. The different sub-stages would exhibit different functioning dynamics with regard to the value network and embedded resources. The stakeholders can take advantage of our research findings to analyze which stage they are currently in and formulate long-term transition plan. Secondly, open innovation around various stakeholders is recognized as an important nurturing strategy for BE development, which has been proposed in existing literature (Rong and Shi, 2015) and verified in this research. Therefore, policy makers and promoters of sharing manufacturing should work to facilitate the formation of interactive relationships among various stakeholders, not including those involved in the traditional supply-chain, but also those with potential and complementary resources such as firms from internet, financial, real estate, and other sectors. Thirdly, as a central stakeholder of manufacturing BE, MTMs can exert significant and widespread impact on the development of BE by acting as the driver of open innovation. To facilitate dynamics at the macro level and focal firm’s strategy at the micro level. Although open innovation has been recognized as an important BE nurturing strategy for focal firms (Rong et al., 2010; Rong and Shi, 2015), few studies have linked the evolution from TMBE to SMBE, MTMs should conduct open innovation strategies continuously and adaptively. When the embedded resources within BE is relatively poor, inbound open innovation maybe more appropriate for MTMs to enrich the resources and be prepared for next stage. Afterwards, coupled open innovation should be carried out to facilitate the upgrade of both BE’s value network and embedded resources.

Limitations and future research

The findings should be interpreted with the limitation on universality brought by the single case study methodology. For one thing, BE evolution would show different patterns, according to the local institutional and cultural structure, as aforementioned (Rong et al., 2018a). As our case is the BE around a MTM in China, it may not be proper to generalize the research findings without taking the institutional and contextual differences into consideration. Future research should verify our research findings in other institutional and cultural contexts other than China, ideally by conducting cross-national comparative analyses (Meng et al., 2018). Also, our study only includes a single case which successfully achieved evolution from TMBE to SMBE, which may result in success biases of our research findings. For the purpose of theoretical replication, case selection may include extreme situations and polar types (Pettigrew, 1988; Eisenhardt, 1989; Leonard-Barton, 1990). Hence, future studies are suggested to include both successful and failed cases of evolution from TMBE to SMBE in order to offer more comprehensive insights with regard to our research questions.

ACKNOWLEDGEMENT

This work was supported by National Natural Science Foundation of China (Grant No. 71572093).

REFERENCES


Cite this article as:

Submit your manuscript at
http://www.academiapublishing.org/journals/jbem