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The Systematic Model (ESFE) for Implementation of open innovation in Yuchai Group in China

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Findings: **The results show that, from the systematic view, the dynamic process of open innovation is divided into four interconnected parts: elements, integration, evaluation of performance and adjustment to the environment. For Yuchai Group, the element acquisition are much more vital than the development of ideas. Moreover, the structural integration consists of internal integration and external integration according to the relationships of knowledge under the value chain. Additionally, the evaluation of performance focuses on knowledge production, not only about pecuniary results related to patent production, but also the change of modules as the knowledge base. The adjustment of open innovation in both the market and the political environment is a long but gradual process. Therefore, it is appropriate for organizations to adopt a systematic model for management of open innovation.**

Originality/value: **The authors have built a systematic model (ESFE) of open innovation and elucidated some effective practices of open-innovation management based on the case study of a Chinese firm.**

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I. Introduction

Modern enterprises rely on updating knowledge and innovation to sustain their competitive edge instead of by static skills or resources. In this regard, the concept of open innovation introduced by Chesbrough (2003) underpins the use of not only both external and internal ideas but also internal and external paths to the market applicable to the firms' innovation. Within the approach of open innovation, the inflow and outflow of knowledge may create opportunities for cooperative innovation for partners, customers and suppliers (Gassmann and Enkel, 2004), which would, therefore, accelerate internal innovation (Chesbrough, 2006). Two types of open innovation are defined: inbound and outbound (Chesbrough and Crowther, 2006; Andreet al., 2011; Popa et al., 2017). Considered as a new paradigm of innovation, open innovation has been categorized into three interconnected branches by scholars: 1) change of theoretical understanding of the nature of open innovation; 2) reasons for the implementation of open innovation; and 3) performance management of open innovation.

It is vital if not pivotal for firms to exchange knowledge, ideas and concepts with entities operating in the ever-changing environment in open innovation, and the breath and the depth of the search for the elements are emphasized by Terjesen and Patel (2017). It is important to invest in relationship with partners by gathering, developing, controlling and disseminating external knowledge in the dynamic process of innovation (Bakiciet al., 2013; Dahalander and Gahnn, 2010; Howells, 2006). Some scholars suggested that firms should systematically cultivate favorable inner environments, such as IT infrastructure, attitudes to risk, innovation and open belief, willingness to share, good governance, and rule of training, to create knowledge and capture business values(Oliveira et al., 2017; Guannan Xu et al., 2017; Kratzeret et al., 2017). We could thus deduce from the literature that open innovation is a dynamic process involving new knowledge in and out of the boundaries of firms and influenced by many factors, such as the elements for input, relationship with the environment, and the inner activities, but there lacks models to illustrate the dynamic process with multiple factors. Open innovation would increase labor division, improve market institutions for trading ideas, and foster collaboration across geographical distances with new information technologies in the era of globalization (Carayannis and Campbell, 2009; Dahlander and Gann, 2010). Firms could attain pecuniary and indirect benefits because oportunities let them gain access to exogenous expertise, to reduce time and cost, to promote learning, to enhance technology competence, and to share

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uncertainties and risks (Howells et al., 2008; Keupp and Gassmann, 2009). Nonetheless, contention exists in the literature, of which the most controversial is on the performance, because many uncertainties are involved for economic or innovative returns, to the point that the concept of ―paradox of openness‖ was suggested (Arora et al., 2016). Some scholars found that open innovation could increase the transaction cost, damage the interests of the innovators due to weak protection for intellectual property, and lead to knowledge leakage (Harmancioglu, 2009; Almirall & Casadesus- Masanell, 2010; Sisodiya et al., 2013). Others found difficulties in profiting from external knowledge, for the reasons below: 1) the lack of paths and motivation to exogenous innovation (Boudreau & Lakhani, 2009); 2) imbalance and mismatch between open-innovation and internal innovation (West & Gallagher, 2006; Enkel et al., 2009); 3) the lack of transfer of exogenous ideas into the firm's products and service strategies. It is plausible that Kübra and Nihan (2016) even illustrated 13 types of bars for the implementation of open innovation. Open innovation alone is insufficient for the performance of firms, because it is affected by many factors (Fu,2012) – not only by the innovation inputs, such as R&D and the inflow of qualified knowledge (Cheng and Shiu, 2015), and environmental variables, such as knowledge-rich surroundings and appropriate resources and capabilities (Molina-Castillo et al., 2011), but also more importantly by the efficiency of firm's inner innovation activities, such as relational capability, flexibility for responsiveness and adaptability, business models attuned to open strategies, et cetera (Sisodiya et al., 2013; Tina and Nicolai, 2015). We thus could find from the literature that performance is vital for a firm to adopt and moderate the management on open innovation, but performance is affected by numerous factors, therefore, a holistic view is warranted. Open innovation is a complicated and dynamic process in the context of global, technological, and market dynamism (Rodrigo-Alarcón et al., 2017). Just as

> "open innovation is on its way to become innovation‖ (Huizingh, 2011). The complexity theory, innovation, and other streams of literature can help overcome many of the gaps in innovation research (Foss and Saebi, 2017), thus, establishing a systematic model of open innovation to understand the feedback relationship between the innovation firm and the environment is considered an area for worthy exploration. Hence, we utilized content analysis for elucidating the development of open innovation based on a case study of the Yuchai Group in the People's Republic of China to illustrate the validity of the theory.

a) *Literature Review for a Systematic Model of Open Innovation*

Innovation has gradually stepped into the central stage of economic activities since the industrial evolution, with the development of economic and social environments, since the ideas and models of innovation exert potential influences on firms' success (Villarreal and Calvo, 2015). Those innovation activities confined in the boundary of the firm are referred to a closed model such as the linear model (Bush, 1945) or the chain-linked model (Kline and Rosenberg, 1986). From the beginning of 1990s, openness of innovation has become the frontier of research. Since knowledge is distributed and fragmented among persons and institutions, the innovation activities need coordination and integration of the actors with dispersed knowledge in different institutions or different departments. Hence, the knowledge production of model 2 (Gibbons et al., 1994), integrated model (Rothwell, 1994), techno-economic network model (Callon, 1994), or National Innovation System (Freeman, 1995) emerged in the literature, which emphasized not only inclusive innovation but also partnerships and linkages in a network of innovation agents. Since the early 2000s, the environment of innovation got much attention, Chesbrough (2003) generalized open innovation to illustrate the internal and external relationships and the process of knowledge exchange. Nowadays, some models with the systematic views are emerging, such as model 3 of knowledge production in the Glocal age (Carayannis and Campbell, 2006) and the Quadruple Helix Model(Carayannis and Campbell, 2009, 2011, 2012) to explain the more complicated process and the influence of numerous factors.

From the closed model to the open model, then to the systematic model, the principle and feature of innovation has been adapted to coordinate and integrate the internal business functions with the adaptability to the environment(see table 1) (Chesbrough, 2003; Carayannis and Campbell, 2011; Abulrub and Lee, 2012; Huang, et al., 2013;

Kübra Simsek, Nihan Yildirim, 2016). The elements for input are extended, including whether the type or the scale and the derivation of profit have been pluralism, whether the priority between technology and market focuses on the joint, and whether IP strategies are always mixed to attain the foreseeable payoff and to decrease the uncertainty in innovation.

Table 1: Comparison of Different Models on Innovation

	Closed Model	Open Model	Systematic Model
Employee and Talent	Learned people such as scientists and	Not all learned people workinthe companies;	The emphasis is notonly on
	technicians in our field work for us.	somebright individualsare outside the company.	learnedpeoplefromscientific and technological disciplines,butalso on information or standards.
Feature of Participants	Homogeneous	Similar or heterogeneous	Heterogeneous and hierarchical
Profit derivation	Discover, develop and ship from internal R&D.	External R&D could create significant values; internal R&D is needed to claim someportion of that value.	Integration of external knowledge and internal R&D; people, culture, and technology as three base blocks.
Priority between technology and market	Create the best ideas, discover newtechnology, commercialize an innovation, launchit in themarket first.	Build a better business modelfirst, best use the internal and external ideas.	Establish thejunction ofvalue first in order to adjust to the dynamic environment
IP strategy	Exclusive IP strategy, control our intellectual property so that the competitors do not profit from it.	Assignment and consignment of IP strategy, profit from others'use of our intellectual property.	Mixed
Payoff	Not interested in knowledge application and innovation.	Contract or flexible	Grants

(Source: Chesbrough, 2003; Carayannisand Campbell,2011; Abulrub and Lee, 2012; Simsek and Yildirim, 2016)

As the core of innovation activities, the model of knowledge production has changed from Model 1 to Model 3 (Carayannis and Campbell, 2011; Gibbons et al., 1994) (see Table 2), and the appreciable progress has been achieved on knowledge management. Model 1 is on the basis of closed innovation: while Gibbons et al. (1994) emphasized knowledge is produced in trans-disciplines and trans-organizations, Carayannis and Campbell(2011) found the spatial dimension of knowledge innovation in the context of knowledge-based and knowledge-driven, global economy and society. The concept of knowledge fractals proposed by Carayannis and Campbell (2011) implies that knowledge owned by persons or institutions is only a part or fractal of the micro-subsystem and the openness is the inherent character of innovation. The innovative organization, even full of knowledge, needs to obtain information from the environment, develop the flexible ability to coordinate and cooperate with the other institutions to conceptualize, design, and manage the "knowledge stock" and "knowledge flow" to exploit the effect of innovation synergy. Accordingly, open innovation is always on the evolutionary path of coexistence, co-evolution, and co-specialization of different knowledge paradigms.

Table 2: The Changing Process of Model of Knowledge Production in Innovation System

	Model 1	Model 2	Model 3
Knowledge type	Normative, rule-based, scientific knowledge. Separate knowledge production and application. Dissemination is through discipline-based channels. Quasi-permanent, institutionally-based team.	Knowledge structure of discipline; consensual, continuous, negotiated knowledge. Integrated knowledge production and application. Dissemination is through collaborating partners and social networks. Short-lived, problem-defined, non-institutional team.	Knowledge fractals:—Knowledge fractals emphasize the continum like bottom-up and top-down progress of complexity. Each-sub component (sub-element) of a knowledge cluster and innovation network can be displayed as a micro-level sub-configuration of the knowledge clusters and innovation networks.
Feature of knowledge Production	(1) Basic university research;(2) —pure basic research‖; (3) with in a single firm;(4)basic university research that is interested in delivering comprehensive explanations of the world, structured in a —disciplinary logic	Universities and —‖ entrepreneurial university over ial: (1) —Knowledge produced in the context of application ‖;(2) —trans- disciplinarity‖ ;(3)—heterogenei ty and organization diversity ‖; (4)—social accountability reflexivity‖ ; and (5) —quality control‖	Socioeconomic, political, technological, and cultural trends and conditions can shape the co-evolution of knowledge with the —knowledge-based and knowledge-driven‖, Glocal economy and society.
Organization of knowledge Production	Single discipline-based; Hierarchical and conservative team organization	Trans-disciplinary, involving a diverse range of specialists. Non-Hierarchical and transient team organization	Flexible organization networks within a multilateral, multinodal, multimodal, and multilevel systems approach to the conceptualization, design, and management of real and virtual, —knowledge stock‖ and —knowledge flow‖ modalities.
Evolutionary path of knowledge innovation	Innovation seen as production of —new‖ knowledge; Research practice should be —good science‖. Newtonian model of science specific to a field of enquiry. Research practice conforms to norm of discipline‘s definition of —scientific‖.	Innovation also seen as reconfiguration of existing knowledge for new contexts; universityre presents a partial extension of the business elements to the world of academia, the academic firm could serve as an example for an extension of the world of academia to the world of business.	The knowledge is —relativity of truth‖ in essenceand the path is —pluralism‖, such as coexistence, co-evolution, and co-specialization of different knowledge paradigms and different knowledge modes of knowledge production, knowledge use and their resultant co-specialization.
Context	Problem formulation governed by interests of specific communities. Problem set and solved in (largely) academic context.	Problem formulation governed by interests of actors involved in the practical problems. Problem set and solved in application-based contexts.	Problem formulation governed by Glocalsystems within the simultaneous processing of knowledge and innovation at different levels (for example, global, national, and sub-national) and the stocks and flows of knowledge with local meanings and global reach.

(Source: Carayannis and Campbell, 2011; Gibbons et al., 1994)

Although Model 3 of open innovation (systematic model) has been suggested, whilst for the implementation of such a model, the need remains to develop a theoretical framework of innovation to illustrate the dynamic relationship among the multiple factors in or out of firm, and the environment with its attributes (social, economic, cultural), scales (local, regional, national and global), and types (inner environment, industrial, and trans-industrial).

b) A Research Framework of a Systematic Model for Open Innovation

A system is an entity with interrelated and interdependent parts (Bertalanffy, 1968). It consists of elements, the relationships between which characterize the structural feature. A system is always defined by its boundaries, and the world out of the boundaries for a given system is regarded as the environment; there are exchanges between system and its environment via materials and energy. Function represents the dimension, efficacy and ability with which the system interacts with its environment, and affected by the quality of the elements, feature of structure and environment, often measured by the scale, growth, efficiency, et cetera. System is dynamic, and it is the function of the system that decides whether a feedback is positive or negative. The concept of the innovation system was introduced by Lundv all in 1985, and has been extended as the national system of innovation (Freeman, 1995) and industrial innovation systems or regional innovation systems (Cooke et al., 2004). So innovation systems could be analyzed at different levels: firm, cluster, sub-regional, national, and international.

This paper focuses on how firms in a specific industry implement innovation activities in the open system. In essence, knowledge production is the core work in the innovation system, and as a dynamic system, there are huge flows of technology and information along with capitals and human resources. Moreover, the function of innovation mainly results from the interactions between the actors to realize an idea into a process, product, or service on the market.

c) Processes for Open Innovation System Management

Loasby (2000) argued that an organization is a knowledge-interpretation system that creates knowledge from the division of labor and evolution in the open world. Chesbrough (2003) defined the processes of open innovation: 1) forming relationships, 2) relying on venture capitalists, 3) managing intellectual property, 4) the metabolism of new knowledge; and 5) establishing new architectures and business models. Lane et al. (2006) simplified the process of open innovation into exploratory learning, transformative learning, and exploitative learning, and suggested that three processes for the absorption by a firm is identifying, assimilating, and applying external knowledge.

According to the general system, we could build the systematic model of open innovation (ESFE) as a skeleton for analysis of the relationship and mechanism in open innovation.

1) Element Acquisition: With information technology, it is not difficult for firms to collect the information on the market, and on the social, political, and administrative milieu to filter, judge, diagnose and integrate for innovation. Acquiring knowledge, especially the intellectual property, is imperative for open innovation, but under the protection of intellectual property, there is a little hope to attain the real innovation patent. Acquiring talents is the main aims for searching activities because talents with ideas are the main sources of the thoughts for core innovation, and head-hunting behavior always involves a wide-range search on the targeted university or personnel via social relations, information networks, and excellent communication skills. It is also important for firms to search for such exogenous R&D, not only to increase funding, but also to discern the trend of innovation.

2) Structure Integration: According to Porter's view of the value chain, every organization in an enterprise could be viewed as a knowledge base to modularize the enterprise knowledge and has its functions. In a systematic model of open innovation, every module with its special innovation activities in the value chain has the chance to obtain exogenous knowledge with with special demands. When the exogenous elements outside are put into the firm, the management activities need not only to distribute into different modules, but also ascertain in the most necessary chain. So the firm could develop the most efficient absorptive ability and found the solid base for its innovation performance.

3) Function Evaluation: The evaluation of performance is the core of the management of innovation, and the key performance index (KPI) is always seen as the benchmark to adjust or even change of the management activities. The KPI mainly consists of economic performance (such as the yield, volume of production, profit, etcetera), knowledge output (such as patent production, knowledge diversity, ideas change in organization, etcetera), and social effects (such as the salary level of the staff, enthusiasm enhancement, entrepreneurship enhancement, etcetera).

4) Environment Impact: The performance of open innovation would ultimately be tested by the environment, and the activities of open innovation in the firm would also influence the environment.

Hence, the ways in which an open-innovation system adjusts to the uncertain environment or even surmount the environmental constraint is also an issue. Entering a higher platform, being a leader of the industry, and acquiring honors would richen the intangible asset and enable more opportunities to take advantage of environment for elements.

II. Methodology

a) *Case Study Method*

As a research method, case studies can be used for an up-close, in-depth, and detailed examination of open innovation, and its related contextual conditions in a company. Hence, we chose Guangxi Yuchai Machinery Group Co. Ltd. (Yuchai Group), headquartered in the city of Yulin, in Guangxi Zhuang Autonomous Region in P. R. China, as our case study for the reasons below.

1) Experiences from China are typical and useful for open innovation. China started its economic reform and opening up in 1978; this is especially exemplified by China's entry into the World Trade Organization (WTO) in 2001 which witnessed a more open and rapid process of change in reform since then. Given the several decades of reform and opening up, in Chinese industry, the discursive processes of knowledge creation has shifted from learning, imitation to innovation, and today many Chinese products compete successfully in the global markets in terms of speed, cost, quality, and innovativeness (Bi et al., 2017; Chung and Tan, 2017). Xu et al. (2017) argued that the progress achieved in China might be attributed to the innovation ecosystem: attention to the integrated value chain, the interactive network in the fast-developing industries and in a multi-layered innovation ecosystem, and the favorable environment cultivated at the national level. Experiences from China are typical and useful not only for the nations that are catching up, but also for most companies that are likewise, because in the age of fractal knowledge, only a few knowledge that company has is leading in the fragmentation of knowledge.

2) The Yuchai Group has made a great technological progress since China's economic reform and opening up to the world. As a large-sized modern enterprise, the Yuchai Group has not only integrated the engine-industry chain with the petro chemical-industry chain but also diversified its industrial operations, which include a manufacturing base for internal combustion engines with the most complete spectrum of products in China, and the company ranks 17th among China's top 500 machinery manufacturers. As a domestic leading industrial conglomerate with over 20,000 employees and 30 wholly-owned, holding and joint-stock subsidiaries, the Yuchai Group has achieved sales revenues of 40.124 billion yuan in 2014 through group operations and open-innovation management. The Yuchai Group is a national high-tech enterprise with tremendous R&D strength, owning over 2,000 authorized patents, several of which filled in the domestic technical gaps. It also has numerous domestic and overseas products and technology R&D centers, which focus on independent technologies and are geared to global cutting-edge technologies. Now, the Yuchai Group is advancing the "second start-up", concentrating on "transformation and upgrading" to adjust the industrial strategy to the more competitive and open environment. Hence, researching on such a company would provide deep insights into open innovation in China.

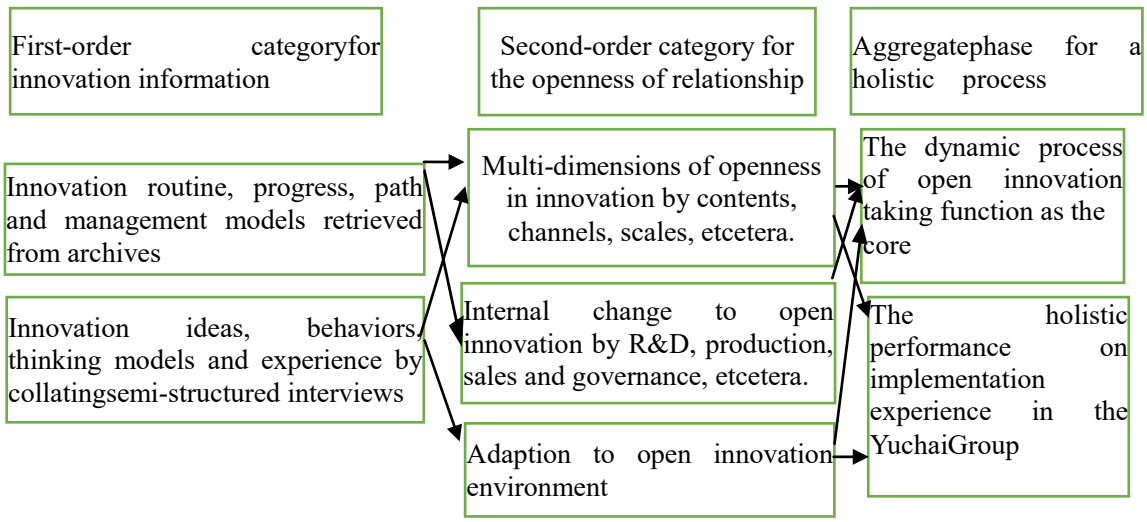

Figure 1: Three Steps for Data Coding

b) Data Collection

Data collection was conducted from January 2015 to March 2016. Archival data, semi-structured interviews were used in the process as in figure 1.

1) Archival data

In order to trace the historical path of open innovation in a company, archives represent the most comprehensive channel to acquire effective information and data, because archives contain primary-source documents that have been accumulated over the course of an organization's innovation and its environment and reflect the organization's evolution. We collected 65 documents in the Yuchai Group, including reports, articles, media reports, stories and Web materials: some were downloaded from the official website, others were offered by the general office of the firm. Those documents contained general introduction, production introduction, operation data, production quality reports, innovation processes, annual innovation reports, meeting notes, memos and annual reports. From the indexed archives of the Yuchai Group, we created categories for filing, searched and retrieved the appropriate issues, remarked the milestone in the process of open innovation to clear the path of open innovation, and analyzed the difficulties, challenges and successes in the open innovation from the systematic view. By analyzing the archival data, we found major problems of concern to the firm included relationship building with external organizations, effective management of changes, proper judgement on the performance and optimal ways to adapt to the environment, which could be inducted as a systematic model: channel of elements input, absorption and assimilation of the knowledge structure, and the performance with environmental challenges.

2) Semi-structured interviews

Unlike rigorously-structured interviews that do not allow diversion of topics, a semi-structured interview offers an open framework of themes which allows the interviewer to explore new ideas. We conducted in-depth semi-interviews twice for searching information on the open innovation in the Yuchai Group. The characteristics of the interviewed participants are listed in table 3. We also had the opportunity to conduct non-participant observation on some operating situations in the laboratory and production departments for supplementary information.

Table 3: Characteristics of Interview Participants

	Number	Gender		Position		Length of employment (year)				Immigration	
		Male	Female	Manager	Worker	≤5	5-10	10-20	≥20	Local	Immigrant
First time	25	20	5	18	7	4	11	8	2	7	16
Second time	30	24	6	20	10	5	10	12	3	7	23

The first round of interviews was conducted from15th to18th in January in 2015 with the main aims of judging whether open innovation happened in the Yuchai Group and the ways in which it took place. The interviews consisted of two parts: 1) we ran a one-hour group interview with 25 members from production and innovation management departments including the vice president, product manager, directors of sales, director of human resources, directors of product research and project; 2) in the following days, we conducted individual interviews with the respective managers from the group to explore the information on innovation in each modelof the value chain in the Yuchai Group, with the focus on where and what the open innovation involved.

The second round of interviews was conducted from 5th to 8thin March in 2016 with the main aims of obtaining detailed information on implementation of open innovation, identifying the challenges in its implementation, and collecting more comprehensive experiences on the successes or challenges of open innovation in the Yuchai Group. The interviewees included 30 people, including the vice president, and production and innovation management department from the first interview, while the others were new interviewees from whom were solicited more detailed information on the implementation of open innovation, such as the technical director, technical worker, R&D personnel, production director, marketing personnel, etcetera. Each interview was conducted individually and lasted approximately one and half to two hours, and designed to elucidate the interviewees' perception and opinions of their own department or agency for open innovation. In line with the qualitative nature of our research and for avoidance of digressing into trivial conversations in the process, the semi-structure interviews were designed with sets of questions on open innovation management which were divided into three parts: where, which and how or why, as summarized in Table 4. The first set of questions was designed to

collect basic information on where the open innovation took place and what the scale of openness was; the second set was designed to elicit the depth of content of open innovation; and the third set to explore how the breadth and depth of innovation were interwoven into the practice. Although the interview protocol was designed with major themes in mind, during the interviews, questions were governed by the actual situation instead of any specific orders (Gummesson, 2000).

Table 4: Semi structure Questionnaire on Open Innovation

	Where	What(which)	How
Elements	Where does the R&D(talent, information, knowledge, etc.) come from? University, other companies, National Internal Combustion Engine Association,or government? Does the Yuchai Group have information infrastructure for innovation?	What types of R&D (talent, information, knowledge, etcetera) are of the greatest concern? What is the main channel or derivation of the technological-market information?	What special tools to establish the R&D (talent, information, knowledge, etc.)? How about the technological training of the skilled workers?
Structure	Where tocombine the external R & D (talent ,information, knowledge, etc.) into the internal innovation and production process? Which moduleismainly focused on for innovation?	What standards to use and combine the inbound elements? What standards to outbound R&D (talent, information, knowledge, etc.)?	What tools can be used to combine the elements and the products? How to implement outbound in novation and inbound innovation?
Function	Where is the value chain that affects the function to the greatest extent? Does the information technology satisfy the need of the enterprise? Does the Yuchai Group have strategic planning for the industry of internal combustion engines?	What are the dimensions for performance management ? What are the problems in management for the innovation in the industry of internal combustion engines? What problems have the Yuchai Group encountered in open innovation? What is the technologi callevel of the Yuchai Group? Compared with the same industry, to what extent dotechnical gaps exist in the Yuchai Group?	What is the special in performance management in open innovation? How about the quality management in internal combustion engines? How about the speed of production for new products of the enterprise? How about the O2O logistics development of the industry of internal combustion engines??
Environment	Where are the opportunities and challenges in the environment? Where is the market for the Yuchai Group? What level are the Yuchai Group competing for, local, regional, national, or international? What do you think about the political environment? What do you mainly think the market adaptation of Guangxi Yuchai Group?	What is the position of the company in the competition environment? What mainly are the customers' new requirements for Guangxi Yuchai Group? What are the reasons for the success of Guangxi Yuchai Group industry of internal combustion engines? What is the threshold for entering the industry of internal combustion engines?	How about the change of market of the internal combustion engine? How to get along with the change of the political environment, or of regulations?? How to adjust or control the environment most effectively?

c) Data Analysis

A testable, relevant and valid theory would be developed without the intimate connection with empirical reality (Eisenhardt, 1989). Through constant comparison (Glaser and Strauss, 1967) and content analysis (Krippendorff, 2004), researchers may enhance data interpretation and transform an empirical process into scientific results (Golden-Biddle and Locke, 2007). Through the systematic, iterative comparisons of data, we made data coding into categories and constructed an integrative, theoretical framework by the steps below. Firstly, we collated and sorted the raw data for the most information on the implementation of innovation in the Yuchai Group, especially on the ideas, cognition, behaviors, and routines evolved during the innovation process which indicated similar meanings into first-order activities or categories. Secondly, based on the collected information, we sought to illustrate the relationships, such as the channels, linkages and interactions with the environment, in the dynamic input-output process of innovation to capture the flow of innovation activities and evolution of organizational routines, which could lead to the development of second-order themes by formulating researcher-induced concepts at a more abstract level. Finally, with the method of constant comparison (Strauss and Corbin, 1990), we analyzed the ways in which existing shared schemata of innovation was overturned and then recreated by focusing on two aspects: internal innovation activities, and changes of management, in which a systematic framework was formulated to characterize open innovation based on the second-order themes of innovation; additionally, we discerned some special experience in the Yuchai Group.

III. Results

a) Element Acquisition with Five Models

The Yuchai Group used four basic models to collect the specialized information and ideas on the technology on diesel engines from the relative organizations inside and outside the Guangxi Province as follows:

1) Purchase directly and then re-innovate
Owning to the intellectual property, the original knowledge underlying the innovative product could hardly be obtained but the innovative product itself could be purchased. Accordingly, firms could purchase the product and make a second-hand innovation to rapidly master the new technology. For example, in order to improve the production efficiency of the diesel engine, the Yuchai Group bought the complete set of equipment and the full set of product technology worth 120 million US dollars from the Ford Motor Brazilian diesel engine plant in 1992. Through intensive studies, the Yuchai's technical teams improved the technological capacities, adopted the advanced technical knowledge, upgraded the current products and technologies, and finally made great progress in combustion technology, electronic control technology, structural design, fuel injection technology and emission control technology.

2) Collaborative innovation based on entrusted project
As for the original ideas, based on the entrusted project, the Yuchai Group established strategic cooperative relationships with enterprises such as AVL, FEV and BOSCH from Germany and research institutions including UK's Brunel University, China's Tsinghua University, Shanghai Jiao Tong University and Tianjin University, etcetera. By the means of technological transfer, entrusted design and joint development, the Yuchai Group's R&D teams learned the high-quality knowledge from the exogenous institutions, and made the external knowledge localized. It followed that such new knowledge was helpful for the cultivation of the independent innovation capacity of the firm.

3) Production alliance and information sharing
The production base is always seen as the knowledge cluster for information-sharing. By co-building the production base with suppliers in and out of China, the Yuchai Group has utilized differential knowledge for obtaining the comparative advantage, to lower the cost, strengthen the functions of production, and satisfy the market needs of different regions with more diverse products and services. More importantly, strategic alliances could expand its R & D network and its cooperation with other companies, induce information sharing, integration and utilization, and increase the efficiency in the knowledge flow. In 2011, the Yuchai Group established a production base for marine engines in Zhuhai and Ziyang with Wärtsilä Corporation and China South Locomotive & Rolling Stock Corp. Ltd. respectively.

4) Public R&D acquiring
It is an important channel to apply for public funds for open R&D which could enrich the capital for innovation.By2010, the Yuchai Group had acquired more than 110 million RMB sponsored by the government to focus on the technological innovation, technology transfer and standards, which dictate the trend of demand for innovation and the foreseeable market. For example, during 2004-2012, the Yuchai Group had had 10 projects from 863 National Science and Technology Innovation Programs(such as "product development of the CNG engine for large-scale buses" in 2006, "technology development

of heavy commercial-vehicle diesel engines" in 2008, "key technology research and prototype development based on diesel engine homogeneous compression ignition engine in 2012"), and five projects from the National Development and Reform Commission, three projects from the Technological Standardization Administration of China, and 38 projects from the Guangxi Commission of Industry and Information Technology and 35 projects from the Guangxi Science and Technology Department.

5) Talent hunting and training via projects
Talent hunting and cultivation is the foundation for innovation. The Yuchai Group has usually recruited employees from Chinese universities, especially for those joint laboratories, often take projects as a flexible work for many technicians and talents with domestic institutions. The firm has also created strong R&D platforms for the cultivation on independent R&D technologies that are geared to world cutting-edge technologies. As for the R&D projects of core engine technology, the relative technicians would be sent overseas for training to grasp the international standards and learn advanced ideas and designs.

b) Structure Integration According to Knowledge Relationship

Although innovation relies heavily on the outside world of a company, it is the internal innovation activities that underlie the selection of the best knowledge among the alternatives, configure the best model to integrate the new technology into production, and create the best market opportunities for further development. The scale of open innovation includes the international, domestic and local ones. As in the value chain, the scale of open innovation of each model is determined by the knowledge quality comparable to the rivals at the different levels. Only those models with high-quality knowledge could enter the large-scale open innovation. In the company, the knowledge models with high quality and in the high competitive level could dominate the others, and they spearhead the enterprises' model innovation. Although each model in the value chain has chances for innovation, there are differences on their quality of knowledge. In the R&D model, the quality of knowledge in the Yuchai Group is lower than that in Europe but higher than that in the domestic setting, implying that it needs to acquire high-quality knowledge out of the country and could disseminate some ideas to the domestic companies. In the production model, the Yuchai focuses on the domestic scale for competition. In its sales and after-sales model, the knowledge is higher than that of other regions in western China. The Yuchai Group could outflow its know-how to compete with other firms in the regions (See table 5).

Table 5: The Relationship of Knowledge and Collaborative Innovation of Knowledge Modelin the Yuchai Group

Module	Scale for Competition	Relationship of Knowledge	Model of Open Innovation
R&D module	International level	The quality of knowledge is higher than that of domestic ones, but lower than the international ones.	Inbound innovation: adopt knowledge of high quality and establish strategic cooperative partnerships to co-build talents cultivation bases with well-known universities and research institutions both local and abroad. 1) Take the projects as platforms and make joint efforts in innovation. 2) Build high-level laboratories and technical centers and attract knowledge-oriented talents with appealing payments and welfares.
Production module	Domestic level in China	The quality of knowledge in production module is slightly higher than that of regional ones	Inbound innovation and sharing the technology for manufacturing: 1) Introduce production equipment for the diesel engine from Ford Company U.S.. 2) Be geared to re-innovation in order to satisfy market needs; 3) Establish strategic cooperative partnerships with institutions in and out of China, constructed a production base. 4) With standardized knowledge of production, cooperate with the suppliers of various modules of the Yuchai Industrial Park to co-produce and

Sales modeland after-sales service module	Regional level	The quality of sales knowledge is superior to the ones in west China.	Outbound for business model innovation: 1) Increase the number and service networks of its agents and distributors out of the region via information technology. 2) Build a market end integrated with sales, service, accessories and information and assess the agents regularly 3) Export standardized sales and service knowledge to the other regions via training in training centers and distribution of service centers and accessories logistic centers.

c) Function evaluation on three indexes

According to the experience from the Yuchai Group based on the quality management, the performance management of open innovation focuses not only on the dominant tangible indices such as new knowledge production and monetary profits but also on invisible indices such as diversity and specialization of modules in the value chain.

1) Patents, scientific and technological achievements

The Yuchai Group has accumulated practical experiences in operating major national projects, consolidated its leading position in technology domestically, and contributed to the technological progress of the industry on internal combustion engines. By 2015, the Yuchai Group has had 2300 patents in force, of which over 120 were inventory patents. As a technology core department, the Yuchai R & D Center accounts for more than 60% of the number of patents each year. In addition, the firm won two national prizes for progress in science and technology in China in 2012 and 2013 respectively.

2) Economic achievements

With the implementation of open innovation strategy, the Yuchai Group insisted on satisfaction-oriented profit management but not the optimal profit management in innovation performance management, which nurtured the free air for innovation. Table 6 shows the profitability and the sale volume of engines and the internal combustion engines in the Yuchai Group. Gradual progress may be discerned and are higher than the average in China by 1998, 2006 and 2013.

Table 6: The Profitability Analyses of the Yuchai Engine and of the Whole Industry

Year	The rate of gross profit of the Yuchai engine	The average rate of gross profit in China	The sales volume of the Yuchai diesel engine	The average sales volume of diesel engines by firms in China
1998	–	–	50268	23828
2006	9.50%	6.29%	104674	72857
2013	12.34%	8.80%	178620	155721

3) Evolution of modules in value chain

With the development of open and innovation, the Yuchai Group has expanded its scale tremendously, the internal technologies grow more advanced, and the modules are diversified and more refined. Such modular diversification translates into more bases for the production of new knowledge, and the modular refinemeny translates into more competition for core values and can make more apexes for innovation. Table 7 illustrates the evolution of the modules in the value chain in the Yuchai Group.

Table 7: The History of the Diverse and Refined Evolution of Models in the Yuchai Group

Development stage	Diversity of modules *represents the newly added modules	Specialization of modules
The initial stage(1978-1992)Stock enterprise	R&D module Production module: including Engine module, Automotive	R&D module: Developed the turbo-diesel direct injection engine. Production module: The production ability is 6000 YC61050Q diesel engine. The conversion to the 6105QC

	module, Mechanical engineering module Sales module After-sales service module	automotive diesel engine was a success. Sales module: Exported the engines to Vietnam and Singapore for the first time. After-sales service: First released the three guarantees for engines, which was a pioneer in the industry.
The development stage (1993-2001) Sino-foreign joint-stock company	R & D module Production module: including Engine module, Automotive module, Mechanical engineering module, Energy chemical module, Parts module; Logistic module Sales module After-sales service module	R&D module: Established the systematic reliability engineering of refined production and adopted the project of replacing the diesel engine with gasoline engine and firstly explored the electronic control technology of diesel engine and reached the standards of Euro Ⅰ and Euro Ⅱ. Production module: Produced rear-engines equipped with buses. Sales module: Developed five more specific markets including heavy machinery, light-industry machinery, buses, engines for general purposes, and export markets. After-sales service module: Established a customer service center and pioneered the repair process of engines.
The mature stage (2002-) A mixed-ownership enterprise with a diverse shareholding structure	R & D module; Production module: including Engine module ,Automotive module, Marine power module, Mechanical engineering module, Energy chemical module, Parts module; Logistic module Sales module After-sales service module	R&D module: Developed three core technological plat forms of the combustion system, calibration system of electronic control engine, and power train packaging. Also developed smaller and lighter engines. Production module: Developed 27 series of products with a total of over 2000 kinds of products, covering the markets of trucks, buses, passenger vehicles, mechanical engineering, industrial equipment, agricultural equipment and marine generators. Sales module: Specialized in overseas sales service networks for different countries and households. After-sales service module: Divided the customer service center into automotive engine business with two parts (buses and trucks) and general-purpose engine business with two parts (general-purpose machines and marine-power machines).

d) Environment impact mainly on two dimensions

In an open environment, the innovation of a firm needs to not only adjust the environment, but also influence or master the environment with the innovative power.

1) satisfied the needs for environmental protection

With the core concept of "Green Development & Harmony Win-win", the final aim for open innovation of the Yuchai Group is to satisfy the market needs. As shown in Figure 2, following international standards, the Yuchai Group satisfied the market needs with environmental protection requirements as the domestic pioneer. The engine, as the maple product in the Yuchai Group, is the key module for innovation; against this background, the group has always kept in line with international standards, paid more attention to technological innovation on more energy-saving in combustion, and spearheaded the domestic technological standards and requirements of the internal combustion machines in China. In sum, the Yuchai Group has used the power of innovation to direct the domestic market needs.

2) Adjustment to the economic system reform in China

Alongside the economic system reform in China, the Yuchai Group has re-formulated its organization structure in accordance to the evolution of innovation. The active adaptation to changes may thus have laid a solid foundation for its open innovation to succeed in the institutional reform and product upgrading (See Table 8). For example, the Yuchai Group, restructuring as a Sino-foreign joint-venture limited company in April, 1993, broadened

its vision and enhanced the innovation strategy. Since 2002, under the innovation-oriented national strategy, more innovative departments have been established in the Yuchai Group, such as the national technical center, the state-accredited laboratory, the postdoctoral workstation and the corporate academician and expert work stations.

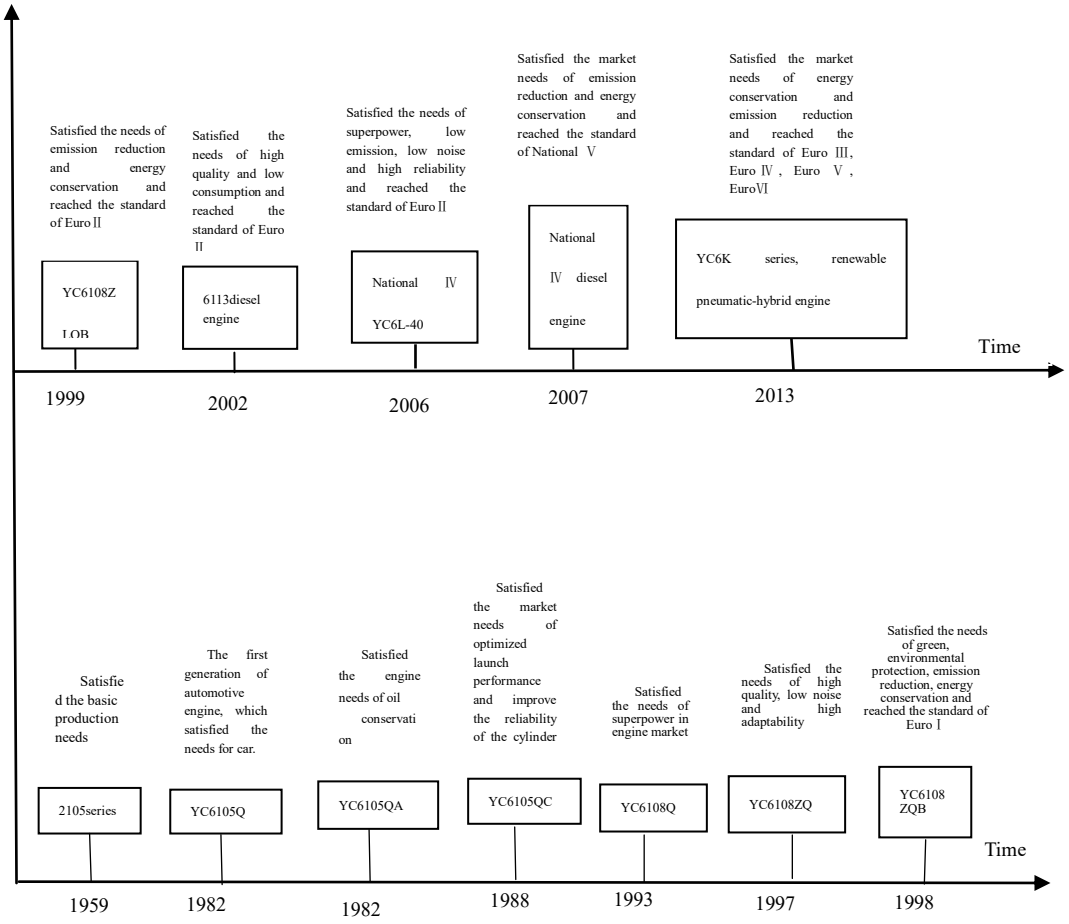

Figure 2: The Historic Path of Adjustment to the Market Environment

Table 8: Historical Changesin the Yuchai Group along with System Reform in China

The system reform in China	The organizational changes and innovative evolution of the Yuchai Group
From 1953 to 1977, China was under the policy of planned economy.	The Yuchai Group was a labor-intensiveenterprisein 1951.The power machine was the main product of the enterprise in 1969. As the plans of production and categories were formulated by the government, the Yuchai Group lacked independent innovation and produced only the diesel engine which met the basic needs for production.
From1978to 1992, China established a market economic system.	From 1978, the Yuchai Group had become a self-management enterprise with full financial responsibility with its independent innovation, and started the innovation journey according to the market rules.
From 1993 to 2001, China stepped from the age of partial opening to the age of full opening.	Transformed into a Sino-foreign joint-stock limited company in April, 1993, the Yuchai Group became a listed company in New York Stock Exchange to target at foreign funds, cooperated with large foreign enterprises, and promoted internal systematic innovation. With the flow of foreign capital and knowledge, it has changed its paradigm from imitating to adapting and exploring new methods to improveits innovative capacity, and grew to be a leading enterprise in the production of internal combustion engines in China.
Since 2002, a innovation-oriented national strategy has played a crucial role.	The internationalized Yuchai Group started to transform into a mixed-ownership enterprise with diverse shareholding structures and adopted the combination of internal and external resources in research, development, production and sales. It built an R&D center, and established strategic alliances with many enterprises and research institutions.

IV. Conclusion and Limitations

According to the literature review and the deduction from the systematic philosophy, the systematic model of open innovation was built to consider all the fragmented factors and the multilevel environment to holistically illustrate the procedure of knowledge input and output, and explain the dynamic process for open innovation. The results show that the dynamic process of open innovation could be divided into four interconnected parts from the systematic view: elements, integration, evaluation of performance and adjustment to the environment. We chose the Yuchai Group as a case study of such an implementation of open innovation: with the mixed tools of the experience analysis of historical records and interviews under the content analysis, we developed an implementation of the systematic model for open innovation in the People's Republic of China. In the case study of the Yuchai Group, the element acquisition are much more than ideas, and the structure integration is bidirectional according to the internal and external relationships of knowledge under the value chain. In addition, the KPI of performance evaluation focuses on knowledge production, not only about the patent production, but also the change of modules as the knowledge base. It is a long and comprehensive process to adapt to changes in both the external marketing environment and the political environment. Therefore, it would be appropriate for organizations to adopt the systematic model for more judicious management of open innovation.

Some limitations of this research are of note. The first limitation is the quality of the sample. As only one company was investigated in the case, the representativeness of the sample needs to be amplified and strengthened in future. The second limitation is that our sample is limited in only one of the contemporary state-owned Chinese organizations, which is insufficient to represent all Chinese companies with different types of innovation. Our analysis does not preclude different interpretations in other settings since this research focuses only on inbound open innovation in China. The third limitation of this research is the lack of an econometric model to analyze the relationship between performance and factors affecting it. Although our findings are consistent with the systematic model, the dynamic process still needs to be further refined, thereby making the causal relationships between related variables more convincing.

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