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The systematicmodel for implementation of open innovation in Yuchai Group in the People's Republic of China

Lin Zhang

Business School, Guangxi University, Nanning,P. R. China

Email: zhanglin1898@163.com

Xiaojuan Yang

Business School, Guangxi University, Nanning,P. R. China

Email: yangxj@mail.gxu.cn

Dawei Zhang

School of Economic Management, Guangdong University of Petrochemical Technology, Maoming, Guangdong, P. R. China

Email: daweigongzuo@yeah.net

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Abstract

Purpose – This paper aimsto develop a systematic model of open innovation from a systematic view based on the case study of the YuchaiGroup's practices so as to illustrate the knowledge input and output in the open-innovation model.

Design/methodology/approach –The systematic model of open innovation was constructed on the basis of the Yuchai Group's practices in the People's Republic of China from a grounded theory approach.

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

Originality/value–The authors have builta systematic model (ESFE) of open innovation and elucidated some effective practices of open-innovation management based onthe case study of a Chinese firm.

Introduction

Modern enterprises rely on updating knowledge and innovation to sustain their competitive edgeinstead of by static skills or resources. In this regard, the conceptof open innovationintroduced by Chesbrough(2003) underpinsthe use of not only both external and internal ideas but also internal and external paths to the market applicable to thefirms'innovation. Within the approach of open innovation, the inflowand outflowof knowledgemay create opportunities for cooperative innovation for partners, customers and/or suppliers (Gassmann and Enkel, 2004), which would therefore accelerate internal innovation (Chesbrough,2006).Two types of open innovation are defined: inbound andoutbound

(ChesbroughandCrowther, 2006;Andreet al.,2011;Popaet al, 2017).Considered as a new paradigm of innovation, open innovation has been categorized into three interconnected branches by scholars: 1) changing the 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 exchangeknowledge, 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 of innovation are emphasized by Terjesen and Patel(2017).It is important to invest in relationships 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 thatfirms shouldsystematically cultivate favorable inner environments, such as IT infrastructure, attitudes torisk, innovationand open belief, willingness to share, good governance, and rule of training, so as to create knowledge and capture business values(Oliveira et al., 2017; Guannan Xu et al., 2017; Kratzeretet al., 2017). Wecould thus deduce from the literature that open innovation is a dynamic process involvingnew knowledge in and out of the boundaries of firms and is influenced by many factors, such as the elements for input, relationship with the environment, and the inner activities, but there is alackof models toillustrate the dynamic process withmultiple factors. Open innovation would increase labor division, improve market institutions for trading ideas, and foster collaboration across geographical distances with new information technologiesin the era of globalization(Carayannis and Campbell, 2009; Dahlander and Gann, 2010).Firmscould attain pecuniary and indirect benefits because ooportunities are given to them to gainaccessto exogenous expertise, to reduce time and costin development, to promote learning, toenhance technology competence, and to share uncertaintiesandrisks (Howells et al.,2008;Keuppand Gassmann, 2009). Nonethelss, contention exists in the literature, of whichthe most controversialis on the performance,becausemany uncertainties are involved for economic or innovativereturns,to the point that the concept of “paradox of openness” was suggested by Arora et al.(2016). Some scholars found that open innovation could increase the transaction cost, damage the interests of the innovators due to weak protectionfor 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 the effective paths and motivation to exogenous innovation (Boudreau & Lakhani,

2009);2) imbalance and mismatch between open-innovation activities and internal innovation (West & Gallagher, 2006;Enkelet al., 2009) and;3) the lack of transfer of exogenous ideas into the firm's products and service strategies.It is plausible thatKübra and Nihan (2016) even illustrated 13 types of bars fortheimplementation 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 e.g.research and development (R&D) and the inflow of qualified knowledge (Cheng and Shiu, 2015),and environmental variables e.g. knowledge-rich surroundingsand appropriate resources and capabilities (Molina-Castillo et al., 2011), but also more importantly by the efficiency of firm's inner innovation activities e.g. relational capability, flexibility for responsiveness and adaptability, business models attuned to open strategies, et cetera (Sisodiyaet 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 numerousfactors, for which a holistic view is therefore 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).Foss and Saebi (2017) haveshown the complexity theory, innovation, and other streams of literature can help overcome many of the gaps in innovationresearch; thus, establishing a systematic model of open innovation to understand the feedback relationship between the innovation firm and the environment is considered an area worth exploration.Hence, weutilizedcontent analysis for elucidating the development of open innovation based on a case study of theYuchai Group in the People's Republic of China to illustrate the validity of the theory.

Literature Review fora Systematic Model of Open Innovation

Innovation has graduallysteppedinto the central stage of economicactivities since the industrialevolution, with the development of economic and social environments, since the ideas and models of innovation exertpotential influences on firms'success, assummarizedby Villarreal andCalvo (2015).Those innovation activitiesconfined in the boundaryof the firm are referred to asclosed innovation 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 andinstitutions, 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 onlyinclusive innovation but also partnerships and linkages in anetwork ofinnovation. Since the early 2000s, the environment of innovation drawn much attention, and 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(Carayannisand 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, theprinciple and featureof innovation has been adapted to coordinate and integrate the internal business functions with the adaptability to the environment(seetable 1)(Chesbrough, 2003;Carayannisand Campbell,2011;Abulruband Lee,2012;Huang, et al, 2013;KübraŞimşek, NihanYıldırım,2016).Theelements 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 arealways mixed in order to attain the foreseeablepayoff 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 technicians in our field work for us.	Not all learned people workinthe companies; somebright individualsare outside the company.	The emphasis is notonly on learnedpeoplefrom scientific 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	Create the best ideas, discover new technology,	Build a better business modelfirst, best use the internal	Establish thejunction ofvalue first in order to adjust to the

technology and market	commercialize an innovation, launchit in themarket first.	and external ideas.	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; CarayannisandCampbell,2011; Abulrub and Lee,2012; Şimşek and Yıldırım, 2016)

As the core of innovation activities, the model of knowledge production has changed from Model 1 to Model 3(CarayannisandCampbell,2011;Gibbons et al. 1994)(see Table 2), and appreciable progress has been achieved on knowledgemanagement. Model 1 is onthe basis of closed innovation: while Gibbons et al. (1994)emphasizedknowledge is produced in trans-disciplines and trans-organizations,CarayannisandCampbell(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 fractalsproposed by CarayannisandCampbell(2011) implies that knowledge owned by only persons or institutions is 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 obtaininformation or knowledge 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 exploitthe effect of innovation synergy. Accordingly, open innovation is always on the evolutionary path of coexistence, co-evolution, and co-specializationof different knowledge paradigms.

Table 2The 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.	Knowledge structure of discipline; consensual, continuous, negotiated knowledge. Integrated knowledge	Knowledge fractals: "Knowledge fractals" emphasize the continuum-like bottom-up and top-down progress of complexity. Each sub-component (sub-element) of a knowledge cluster and

	Dissemination is through discipline-based channels. Quasi-permanent, institutionally-based team.	production and application. Dissemination is through collaborating partners and social networks. Short-lived, problem-defined, non- institutional team.	innovation network can be displayed as a micro-level sub-configuration of the knowledge clusters and innovation networks.
Featureof knowledge Production	(1) Basic university research;(2) “pure basic research”; (3) withina single firm;(4)basic university research that is interested in delivering comprehensive explanations of the world, structured in a “disciplinary logic	Universities and “entrepreneurial universities” overlap: (1) “Knowledge produced in the context of application”;(2) “trans-disciplinarity”;(3) “heterogeneity and organizational diversity”; (4)“social accountability and 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	Innovation also seen as reconfiguration of existing knowledge for new contexts; universityrepresents 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	The knowledge is “relativity of truth” in essenceandthe 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.

	discipline's definition of "scientific".	business.	
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 thepractical problems. Problem set and solved in application-based contexts.	Problem formulation governed byGlocalsystems 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 meaningsand global reach.

(Source: CarayannisandCampbell,2011;Gibbons et al., 1994)

Although Model3 of open innovation (systematic model) has been suggested, whilst for the implementation of such a model, theneed remains todevelop a theoretical framework of innovation to illustrate the dynamic relationship among themultiple factors inor outof firm, and the environment with its different attributes(social, economic, cultural), different scales(local, regional, national and global) and different types(inner environment, industrial, and trans-industrial).

A Research Framework of a Systematic Model for Open Innovation

A system is an entity with interrelated and interdependent parts(Bertalanffy, 1968). Itconsists of different elements, the relationships or forces between which characterizethe structural feature. A systemis always defined by its boundaries,and the world out of the boundariesfor the givensystem is regarded as the environment;thereare materials and energy exchanges between system and its environment. A function represents the dimension, efficacy and ability with which thesystem interacts with its environment. A functionis affected by the quality of the elements, feature of structure and environment, and is often measured by the scale, growth, efficiency, etcetera. A system is dynamic, andit is the function of the system that decides whether afeedback is positive or negative between the system andits environment.The concept of the innovation systemwas introduced by Lundvall in 1985,and has beenextendedas the national system of innovation (Freeman, 1995) and industrial innovation systems or regional innovation systems (Cooke et al., 2004); 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 the innovation activities in the open system.The theory of innovation system provides us a framework for understanding innovation and technology development result from complex relationships among actors in the system, which include enterprises, universities and research institutes.Inessence, knowledge production is the core work in the innovation system, and as a dynamic system, there are hugeflows of technology and information along withcapitals 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.

Processes for Open Innovation System Management

Loasby (2000) arguedthat an organization is a knowledge-interpretation system thatcreates knowledge from the division of labor and evolution in the open world. Chesbrough (2003) defined the processes of open innovation as: 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 the three processes for the absorption by a firm isabout identifying, assimilating, and applying externalknowledge.

According to the general system, we could buildsuch a systematic model of open innovation**(ESFE)**as a skeleton for analysis of the relationship and mechanism inopen 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 alittle hope to attain the real innovation patent. Acquiring talentsis the main aims for searching activities because talents with ideas arethe main sources of the thoughts for core innovation, and head-hunting behavior always involves a wide-rangesearch on the targeted university or personnel via social relations, information networks, and excellent communication skills. It is 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 enterprisecould be viewed as the base of the modularization of the enterprise knowledge

and has its functions.In a systematic model of open innovation, every module in the value chain has the chance to obtain exogenous knowledge, but different modules have different demands and differenttypes in innovation activities.When the exogenous elements outside are absorbed into the firm, the management activities need to not only focus on structural integration for effective distributionof the elements according to the degree of innovation, but also ascertain the innovative activitiesin the most necessary chain; through this, 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 patentproduction, 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 innovationwouldultimately be testedby the environment, and the activities of open innovation in the firm would alsoinfluence the environment. Hence, the ways in which an open-innovation system adjusts to the uncertain environment or even surmount the environmentalconstraint are a key issue. Entering a higher platform, being a leader of the industry, and acquiring honors would richen theintangible asset and enable more opportunities to take advantage of environment to acquire elements.

Methodology

Case StudyMethod

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

(1)Experiences from China aretypical and useful for open innovation. China started its

economic reform and opening up in 1978; this is especially exemplified by China's entryinto the World Trade Organization(WTO) in 2001 which witnessed a more open and rapidprocess 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 shiftedfrom learning, imitation to innovation, and todaymany Chinese products competesuccessfully in the global markets in terms of speed,cost,quality,and innovativeness (Bi et al.,2017; Chungand Tan, 2017). Xu et al. (2017) has arguedthat the progress achieved in China mightbe attributed to the the innovation ecosystem: special attention is paid to the integrated value chain, the interactive network in the fast-developing industries and in a multi-layered innovation ecosystem, and thefavorable environmentcultivated at the national level. Experiencesfrom China aretypical and useful not only for the nations that are catching up, but also for most companiesthat are likewise catching up, 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 madegreat technological progress since China's economicreform and opening up to the world.As a large-sized modern enterprise, the Yuchai Grouphas not only integratedthe engine-industry chain with the petrochemical-industry chain but also diversified its industrial operations, which now includea manufacturing base forinternal combustion engineswith 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 and30 wholly-owned, holding and joint-stock subsidiaries, theYuchai Group hasachieved sales revenues of 40.124 billion yuan in 2014through group operations and open-innovationmanagement.The Yuchai Groupis a national high-tech enterprise with tremendous R&D strength, owning over 2,000 authorized patents, several of whichhave filled in the domestic technical gaps. It also hasnumerous domestic and overseas products and technologyR&D centers, which focuson independent technologies and aregeared to global cutting-edge technologies. Now, theYuchai Groupis advancing the "second start-up", concentrating on "transformation and upgrading" to adjust the industrial strategy tothe more competitive and open environment.Hence, researching on such a company would provide deep insights into open innovation in China.

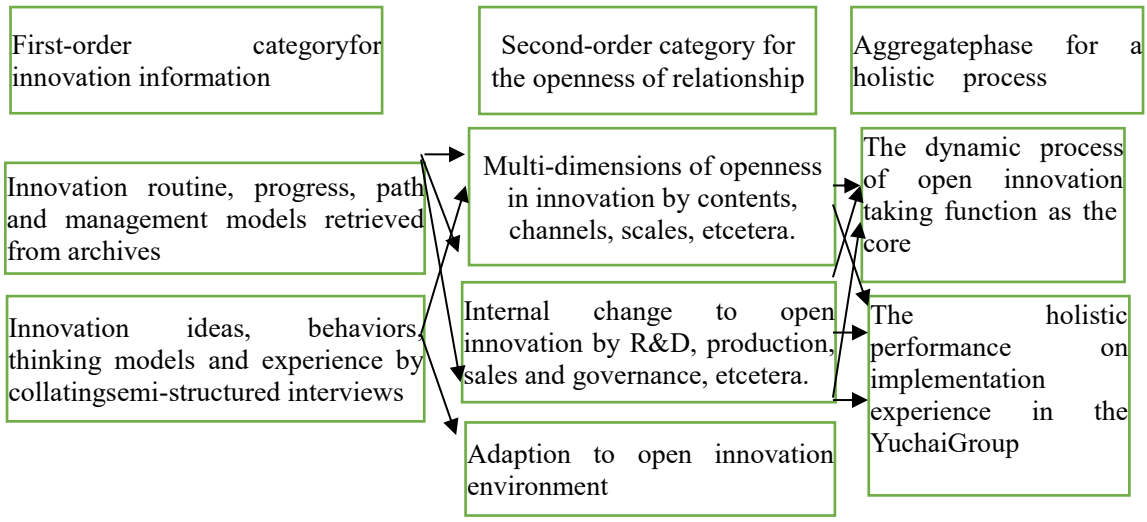

Figure 1Three Steps for Data Coding

Data Collection

Data collectionwas conducted from January2015 to March2016. Archival data, semi-structured interviewswere 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 comprehensivechannel to acquireeffective information and data, because archives always 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 collected65 documentsin theYuchai Group, including reports, articles, media reports, stories and Web materials: some were downloaded from the official website, otherswere offered by the general office of the firm. Those documentscontained introduction, production introduction, operation data, production quality reports, innovation processes, annual innovation reports, meeting notes, memos and annual reports. From the indexedarchives of theYuchaiGroup , we createdcategories for filing, searched and retrieved theappropriate 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 externalorganizations, effective management of changes,proper judgement on the performance and optimal ways to adapt to the environment, which could be inducted asasystematicmodel: channel of elements input, absorption and assimilation of the knowledge structure, and the performance with

environmentalchallenges.

(2)Semi-structured interviews

Unlike rigorously-structured interviews that do notallow diversion of topics, a semi-structured interview offersan open framework of themes which allows the interviewer to explorenew ideas.We conducted in-depth semi-interviews twice for searchinginformation onthe 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 laboratoryand productiondepartments 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 2015withthe main aims ofjudging whether open innovation would happenin theYuchai Group and the ways in which it took place.The interviews consistedof two parts: 1) we ran aone-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 innovationinvolved.

The second round of interviews was conducted from 5th to 8thin March in 2016 with the main aims ofobtaining detailedinformation on theimplementation of open innovation, identifying the challenges in its implementation, and collecting more comprehensive experiences on the successes or challengesof open innovation in the Yuchai Group. The intervieweesincluded

30 people from the first interview, including the vice president, and production and innovation management department, whilethe 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 was designed to elucidatethe 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 ofdigressing into trivial conversations in the process, the semi-structureinterviews weredesigned with sets of questions onopen innovation management which were grouped into three parts: where, which and how or why, as summarized in Table 4.The first set of questionswasdesigned to collect basic information onwherethe open innovation tookplace and what the scale of openness was; the second setwas designed to elicit the depth of contentof open innovation; and the third setexplored how the breadth and depth of innovation wereinterwoven into the practice.Although the interview protocol was designed with major themes in mind, during the interviews, questions were governedby the actual situationinstead 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 CombustionEngine 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 specialtools to establishthe R&D (talent,information, knowledge, etc.)? How about thetechnologicaltraining of the skilled workers?
Structure	Where tocombine the external R&D(talent,information, knowledge, etc.)into the internal innovation and production process? Which moduleismainly	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 outboundinnovation and inbound innovation?

	focusedonfor innovation?		
Function	Where is the value chain that affects the function to the greatest extent? Does the information technologysatisfy the need of the enterprise? Does the Yuchai Group have strategic planningfor the industryof internal combustion engines?	What are the dimensions for performance management? What are the problems in management for the innovation in theindustry of internal combustion engines? What problemshave theYuchai Group encountered in open innovation? What is thetechnologicallevelof theYuchai Group? Compared with the same industry, to what extent dotechnical gaps exist in the YuchaiGroup?	What is the special inperformancemanagement in open innovation? How about the quality management in internal combustion engines? How about the speedof production for new productsof the enterprise? How about the O2O logistics development of the industry of internal combustion engines??
Environment	Where are theopportunities and challenges in the environment? Where is the market for theYuchai Group? What level are theYuchai Group competing for, local, regional, national, or international? What do you think about the political environment? What do you mainlythink 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 YuchaiGroup industryof 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?

Data Analysis

A testable, relevant and validtheory would be developed without the intimateconnection with empirical reality(Eisenhardt,1989).Throughconstant comparison(Glaser and Strauss, 1967) and content analysis (Krippendorff,2004), researchers may enhance data interpretation andtransform anempirical 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 theraw 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 processwhich 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 activitiesand evolution of organizational routines, which could lead to the development ofsecond-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 whicha systematicframework wasformulated to characterizeopen innovationbased on the second-order themes of innovation; additionally. we discerned some special experience in the Yuchai Group.

Results

Element Acquisitionwith Four Models

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

(1) Purchasing directly and then re-innovating it

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, firmscouldpurchase theproduct and make a second-hand innovation to rapidlymasterthe new technology.For example, in order to improve the production efficiency of the diesel engine, theYuchai Group bought thecomplete set of equipment and thefull 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 entrustedproject, the Yuchai Group established strategic cooperativerelationships 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, et cetera. By the means of technological transfer, entrusted design and joint development, theYuchai Group'sR&D teams learned the high-quality knowledge from such exogenous institutions, and made the external knowledge localized. It followed that such new knowledgewashelpful for the cultivation of theindependent innovation capacity of the firm.(3) Production alliance and information sharing

The production base is always seen as theknowledge cluster forinformation-sharing. By co-building theproduction base with suppliers in and outof China, theYuchai Group has utilized differential knowledgefor obtainingthe comparative advantage, so as 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 itsR&D network and its cooperation with other companies , induce information sharing,integration and utilization, andincrease the efficiency in the knowledge flow.In 2011, theYuchai 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&Dacquiring

It is an important channel to apply for public funds for open R&D which could enrich the capital for innovation.By2010, theYuchai Group had acquiredmore than 110 million RMB sponsored by the government with a focus on the technological innovation, technology transfer and standards which could dictatethe trend of demand for innovation and the foreseeable market. For example, during 2004-2012, theYuchai Grouphad had10 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 developmentbased 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 projectsfrom the Guangxi

Commission of Industry and Information Technologyand 35 projects from the Guangxi Science and Technology Department.

(3) Talent hunting and training via projects

Talent hunting and cultivation is the foundation for innovation. The YuchaiGroup has usuallyrecruitedemployees from Chinese universities, especially for those joint laboratories, often take projects as a flexible work for many technicians and talents with domestic institutions.Th firm has also createdstrong R&D platforms for the cultivation on independent R&D technologies that aregeared to world cutting-edge technologies. Asfor the R&D projects of core engine technology,the relative technicians would be sent overseasfor trainingto grasp the international standards and learn advanced ideas and designs.

Structure Integration According to Knowledge Relationship

Although innovation reliesheavily 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 bestmarketopportunities 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 modelswith 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 theYuchaiGroup is lower than that inEurope but higher than that in the domestic setting, implying that it needs to acquire high-quality knowledge out of the country and could disseminatesome ideas to the domestic companies. In the production model, theYuchai focuses on the domestic scale for competition. In itssales and after-sales model, the knowledge is higher than that of otherregions in western China. The Yuchai Group couldoutflowits disseminateand know-howto compete with other firms in the regions (See table 5).

Function evaluation on three indexes

According to the experience from theYuchaiGroup, 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.

Table 5The Relationship of Knowledge and Collaborative Innovation of Knowledge Modelin theYuchai 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 thanthe international ones.	Inbound innovation: adopt knowledge of high quality and establish strategic cooperative partnershipsto co-build talents cultivation bases with well-known universities and research institutions both localand abroad. 1) Take the projects as platforms and make joint efforts in innovation. 2) Build high-level laboratoriesand technical centersand attract knowledge-oriented talents with appealingpayments 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 theYuchai Industrial Park to co-produce and assembly products.
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 ofthe 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 knowledgeto the other regions via training in training centers and distribution of service centers and accessories logistic centers.

(1) Patents, scientific and technological achievements

The Yuchai Group has accumulated practical experiences in operatingmajor national projects, consolidated its leading position in technologydomestically, and contributed to thetechnological progress of the industry oninternal combustion engines.By 2015, theYuchaiGroup has had 2300 patents in force, ofwhich over 120 wereinvention patents. As a technology core department, theYuchaiR&D Center accounts for more than 60% of the number of patentseach year. In addition, the firm wontwo national prizes for progress in science and technology in China in 2012 and 2013 respectively.

(2) Economic achievements

Withthe implementation of open innovation strategy, theYuchai Group insistedon 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 theYuchai 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 theYuchaiEngine and of theWhole 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, theYuchai Group has expanded its scale tremendously, the internal technologies grow more advanced, andthe modules are diversifiedand more refined. Such modular diversification translates intomore bases for the production of new knowledge, and the modular refinemenytranslates intomore competitionfor core valuesand can make more apexes for innovation. Table 7illustrates the

evolution of the modules in the value chain in theYuchai Group.

Table 7 TheHistory 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**
Theinitial stage(1978-1992) Stock enterprise	R&D moduleProduction module:includingEngine module,Automotivemodule,Mechanical engineering module Sales module After-sales service module	R&D module: Developed the turbo-diesel direct injection engine. Production module: The production ability is 6000 YC61050Q diesel engine. Theconversion to the 6105QC 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 EuroI and EuroII. Production module: Produced rear-engines equipped with buses. Sales module: Developed five more specific markets including heavy machinery, light-industry machinery, buses,enginesfor general purposes,and export markets. After-sales service module: Established a customer service center and pioneeredthe repair process of engines.
The mature stage (2002-) A mixed-ownership enterprise with a diverse shareholding	R&D module; Production module: including Engine module,Automotive module, Marine power module,Mechanical engineering module, Energy chemical module, Parts module;	R&D module: Developed three core technologicalplatforms 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

structure	Logistic module Sales module After-sales service module	different countries and households. After-sales service module: Divided the customer service center into automotive engine businesswith two parts (buses and trucks) and general-purpose engine business with two parts (general-purpose machines and marine-power machines).

Environment impact mainly on two dimensions

In an open environment, the innovation of a firmneeds 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 theYuchai Group is to satisfy the market needs.Asshownin Figure 2, following international standards, theYuchai Group satisfied the market needs with environmental protection requirements as the domestic pioneer. The engine, as the maple product in theYuchaiGroup,is the key module for innovation; against this background, the group hasalways keptin line with international standards, paidmore attention to technological innovation onmore energy-saving in combustion, and spearheadedthe domestic technological standards and requirements of the internal combustion machines in China.In sum, the YuchaiGroup 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, theYuchai Group has re-formulated its organization structure in accordance to the evolution of innovation. The active adaptation to changes may thus have laida solid foundation for its open innovationto succeed in the institutional reform and product upgrading (See Table 8). For example, theYuchai 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 establishedin theYuchai Group, such as the national technical center, the state-accredited laboratory, the postdoctoral workstation and the corporate academician and expert work stations.

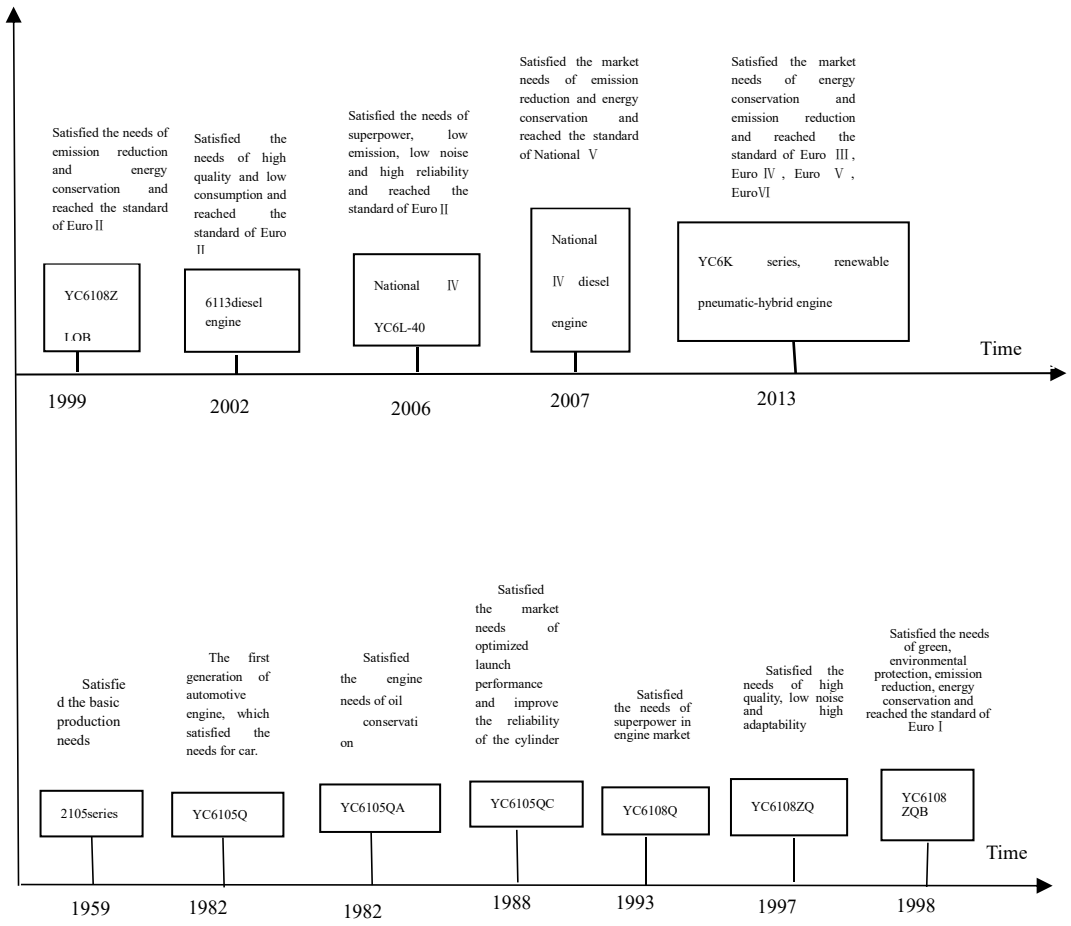

Figure 2TheHistoric Path of Adjustment to the Market Environment

Table 8HistoricalChangesin theYuchai Group along withSystem 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, theYuchaiGroup 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	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

the age of full opening.	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 enginesin China.
Since 2002, ainnovation-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.

Conclusion and Limitations

According to the literature review and the deduction from the systematic philosophy, the systematic model of open innovation was built toconsider all the fragmented factors and the multilevel environment inholisticallyto illustrate the procedureof knowledge input and output, and explain the dynamic processforopen innovation. The results show that the dynamic process of open innovation could be divided into four interconnected partsfrom the systematic view: elements, integration, evaluationof performance and adjustment to the environment.We chose the Yuchai Group as a case study of such an implementation ofopen innovation:with the mixed tools of the experience analysis of grouphistorical 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 theYuchai Group, the element acquisitionare 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. Itis 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 judiciousmanagement 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 representativenessof thesample needs to be amplified and strengthened in future.The secondlimitationis that our sample is limited in only one of the contemporarystate-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 sincethis research focuses only on inbound open innovation in China. The thirdlimitation of this research is the lack of an econometric model to analyze the relationshipbetween performance and factors affecting it. Although our findings are consistent with the systematic model, the dynamic process still needs to befurtherrefined, thereby making the causal relationshipsbetween related variables more convincing.

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