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Attaining a sustainable competitive advantage in the smart grid industry of China using suitable open innovation intermediaries

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ABSTRACT

The integration of various renewable energy technologies and intermittent changes in power supply and demand is becoming increasingly possible through the smart grid system. Innovation in technologies and systems like smart meters, energy controls, and communication systems have been required for scale-up and industrialization of smart grids, whereas Chinese firms still have much room for improvement. This has stimulated questions about the role of open innovation intermediaries(OIIs), whose responsibility is to engage with different types of partners to acquire new ideas and resources from the external environment. With the help of OIIs, Chinese firms in smart grid industry can achieve greatly to renewable energy development and energy conservation. The current study addresses this issue, trying to find the suitable OIIs from different open innovation activities including outside-in, inside-out, and coupled processes in the power supply, grid, and electrical customer side of the smart grid industry in China.

Contents

1. Introduction . . . 1083
2. Current status of the smart grid industry in China . . . 1084
3. Literature review on open innovation and its intermediaries . . . 1085
4. Proposed hypotheses and research methodologies . . . 1086
   4.1. Proposed hypotheses . . . 1087
   4.2. Research methodology . . . 1087
5. Research analysis . . . 1087
   5.1. Collecting data . . . 1087
   5.2. Measurement of variables . . . 1087
   5.3. Data analysis . . . 1088
      5.3.1. Factor analysis . . . 1088
      5.3.2. Cluster analysis . . . 1089
6. Discussion and conclusion . . . 1090
References . . . 1090

1. Introduction

Energy conservation, reduction of greenhouse gas emissions(GHG), and clean production are the major goals for energy development policy in many countries. Nowadays, with the development of digital information technology, satisfying the requirements for reliable electricity, high-quality power supply, and consumer-oriented power demand, has gradually become more feasible. Therefore, the integration of advanced communication, information technology, renewable energy, new material, new equipment via a smart grid(SG) system is becoming a crucial issue, which ensures safe, secure, uninterrupted, and sustainable electricity supplies [1]. Indeed, the smart grid is

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considered to be a requisite to accommodate an increasing amount of distributed and intermittent energy sources in electricity grids, as well as to reliably meet a growing overall electricity demand [2]. In this view, more countries are trying to promote conservation-minded and environmentally friendly practices in their fundamental industries, such as electricity industry, power industry, smart grid industry etc.

With the trend of building renewable-friendly power grids, smart grid is also seriously considered in China. Currently, China has made encouraging progress in smart grid development, especially in the aspect of ultra-high voltage (UHV) transmission system. Nevertheless, in other aspects as distributed generation, microgrid and intelligent demand management etc., the progress is slow and limited [3]. Admittedly, compared with advanced world technology development, China is staying in the initial stage. Some problems prevent the development of smart grid, such as obsolete distribution and consumption equipments, small scale communication system, unaccepted technology standard and index system [4]. Facing these problems, it is urgent for Chinese firms to utilize strategic alliances or joint venture with world partners in order to gain competitive advantage, particularly in technology intensive industry like smart grid.

The core contents of smart grid is to establish open systems, create shared information models, integrate system data, optimize the grid management, and form a network to interactively and instantly connect users and grid firms, which will greatly enhance the interactive operations of power grid and improve the overall efficiency of power grid [5].Then, it is important for smart grid industry to open the boundaries to tap knowledge from the outside and to use the industry market as an extension of the firm will facilitate innovation process [6–8]. At such a reason, development of smart grid industry will be processed more rapidly when there is a communicating platform that allows collaboration and operations among different partners.

In general, there are two crucial features of environment that arise the engagement of open innovation intermediaries(OIIs) in the smart gird industry. First, the unpredictability of technological change, market organization and user uptake makes a single firm cannot innovate in isolation to meet all the demands. Second, an absence of existing linkages between potential users and suppliers that needs to be created or sustained in order to match different types of partners for collaboration [9]. To be specific, OIIs create networks and search for external knowledge by identifying, accessing, and transferring solutions to problems in various stages of the innovation process to their clients [10,11]. With the advantage of facilitating knowledge transfer between technology providers and recipients, and to compensate for the weakness in the system of innovation, the number of firms using OIIs to solve innovation is increasing [12,13]. Accordingly, OIIs act as a communicating platform to profoundly influence the development of technology market.

Although several studies have investigated the role of intermediaries on establishing connections between different kinds of partners in various industries, like biotechnology industry [14], Industry Computed Tomography (ICT) [15], agricultural sector [16], chemical industry [17], oil and gas industry [18], and new product development(NPD) service [19], there has no study on OIIs as a communicating platform at outside-in, inside-out coupled, processes of open innovation activities, especially in smart grid industry. Despite the importance of OIIs, it can be noted that the industries studies are limited. To address the above gap, the aim of this paper is to explore and characterize which and how OIIs can support open innovation activities in the power supply side, grid side, and electrical customer side of the smart grid industry in China. The contribution of this paper is a deepened discussion on the role of OIIs as a communicating platform for innovation, which of great importance for firms to attain competitive advantage.

2. Current status of the smart grid industry in China

Since smart grid technology was introduced into China in 2006, the use of relevant knowledge, ideas, and skills suffers from technological bottlenecks associated with constraining the efficiency and cost reduction [20]. Chinese government plays a leading role to support and ensure the healthy development of smart grid industry. The “12th Five-year Plan of Electricity Industry” announced by China Federation of Electric Power Enterprises, a key government priority is further to develop of the country's power grid with the large-scale construction of a smart grid [21]. Specifically, a strategic framework of smart grid development with one goal, two main lines, three stages, four systems, five connotations, and six sections is put forward, as shown in Fig. 1. For instance, The State Grid Corporation of China (SGCC) has established a technological standard system including “Standard Technology System Planning for Strong Smart Grid” and “Technical Guidelines for Intelligent Substation” to stress the requirements of approval regulation on power grid projects. As to the implementation stage, SGCC and China Southern Power Grid (CSG) are the main promoter and executor of smart grid applications. CSC has built an automatic distribution system with technical features of remote management, remote signal and remote control in Shenzhen and Shanghai, as well as a intelligent substation in Zhongshan to ensure efficient wide-area information monitoring and control [22].

Although smart grids have been developing rapidly in China, there is still a long way to go in some areas which are reflected in the power supply, grid, and electrical customer sides [5]. Some existing gaps and potential solutions are summarized in the following paragraphs.

On the power supply side, the smart grid integrates power supplied by renewable energy sources(e.g. photovoltaic generation, wind power, hydropower, etc.) with conventional power generation into a reliable system. In order to support diversified power supply and change the traditional power mode, necessary related technologies include distributed generation, intelligent demand management, next generation communication and control systems, large-capacity energy storage, and coordination between the grid and conventional plants are required [13,23,24]. In fact, many Chinese firms are still in the technology R&D stage, with immature energy storage technology, system integration technology, and new material technology [22]. As distributed energy has not been substantially applied, large-scale development of power supply is still hindered by lack of advanced technologies and production operation mechanisms. Consequently, Chinese firms may miss development opportunities because many innovative ideas fall outside of their current business models. Thus, cooperation with leading foreign firms using uncertain innovation or emerging technologies may present a major challenge. The most important functions for the recommended OIIs' should include using their connective capability to seek the appropriate partners and launch more innovative projects.

On the grid side, Chinese firms should enhance their capabilities with respect to managing the grid. They need to coordinate planning, scheduling, trading, and transmitting to achieve effective integration. To realize visualization, digital and intelligent grid operation, related technologies are essential, including transmission(advanced detection and inspection technology, intelligent diagnostic analysis and decision technology, life-cycle equipment management, intelligent detection devices and automatic verification devices), transformation(intelligent substation automation technology, intelligent diagnosis), dispatching (energy management systems, wide area management systems, schedule management systems), and information platform(scheduling, security, data transfer, trading and communication) [23–25]. Although Chinese firms have mastered some related technologies, the