

# The impact of product complexity and heterogeneity on online open innovation practices

Wei Wei<sup>1</sup>, Fachen Wei<sup>2</sup>

<sup>1</sup> School of Economics and Management, Tsinghua University, Beijing, China  
*weiwei@sem.tsinghua.edu.cn*

<sup>2</sup> School of Humanity and Social Sciences, Beijing Jiaotong University, Beijing, China  
*fchwei@bjtu.edu.cn*

**Abstract:** Existing studies of open innovation (OI) have ignored the impact of product complexity and heterogeneity on online open innovation (OOI) practices. We divide OOI practices in consumer goods industry into four types, and examine how product complexity and heterogeneity influence the ways that companies carry out OOI. The finding is based on a longitudinal study of 138 cases.

**Keywords:** Online Open Innovation, Consumer Goods, Product Development, Product Complexity

---

## 1. Introduction

Over the past decade, various studies have emphasized that the firms should be open to external innovation (Rigby and Zook, 2002; Chesbrough, 2003). Nowadays, cooperation with externals is core to increase innovativeness and reduce time to market.

The aim of this article is to investigate how product complexity and heterogeneity influence the ways that the companies implement OOI in consumer goods industry. The article is organized as follows. The following section reviews the concept of open innovation and relevant literature. Then, the research design is explained. The subsequent sections propose a framework of online open innovation (OII) and identify how product complexity and heterogeneity act as key determinants of evolution paths of OOI in consumer goods industry based on case analysis. The article concludes by discussing the implications for the study of OOI in consumer goods industry and the limits and

potential for further extension of this work.

## **2. Previous Research on OOI**

To reflect the reality of consumer goods industry, we join four aforementioned streams of research in the present study and examine the role of product complexity in influencing the OOI practices in this industry. Hansen et al. (1999), Zollo and Winter (2002) suggested that teams are appropriate for complex, heterogeneous and infrequent tasks. However, they have not considered open innovation as a context for examining the role of product complexity and heterogeneity.

Researchers have used various definitions of open innovation. A prevailing understanding is that open innovation refers to the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively (Chesbrough, 2003).

Recently, Internet has become a standard medium for the flow of information regarding innovation. Meanwhile, consumer goods industry has been increasingly adopting open innovation. Most of the latest open innovation practices could be found in this industry. Thus, the present study focuses on open innovation via the Internet in consumer goods industry.

As mentioned above, four streams of research provide valuable insights into open innovation. First, a large group of studies focuses on open innovation in high-tech industries (Chesbrough, 2003; von Hippel and von Krogh, 2006), such as pharmaceutical and food industries. Second, the studies on open source software and the rapidly emerging open source goods (OSG) have attracted significant interests (Osterloh and Rota, 2007). Third, online ongoing contests are increasingly adopted by both start-ups and established companies in various industries. These companies turn the winning submissions into reality. Articles on this business practice are emerging (Pisano and Verganti, 2008). Finally, mass customization has been extensively studied by marketing, operations and innovation scholars since 1990s (Pine, 1993). Recently, as technologies reach maturity, customization could allow users design complex 2D and 3D patterns.

## **3. Research Method**

The research was carried out using a multiple-case study methodology (Yin, 1994). Such an approach, in fact, well suits with the exploratory nature of the study and the complexity of the phenomenon under investigation. The unit of

analysis of the study is the OOI practices adopted by the sampled organizations. We construct the evidence from cases into a coherent framework.

A major part of this research – the research on evolution trends of OOI has been executed as a longitudinal multiple-case study. When we analyze the sampled OOI practices, we collect information on their histories, current status and the organizations' plans for future changes. A longitudinal case study provides a single setting with multiple observations over an extended period of time (Yin, 1994).

A derivative aim in the case selection was to create a representative sample of cases. The selection criterion is whether the cases meet our definition of OOI in consumer goods industry. We made significant effort to include more second-hand cases and collect more information on the cases, in order to facilitate theoretical generalization. Our findings are derived from the analysis of 138 cases. Among the cases, 127 cases reflect the practices directly. Another 11 cases are adjacent to the practices under investigation and are used to help conceptualize each practice more clearly.

We employed multiple data collection methods in order to exploit the synergetic effects of combining them via triangulation (Yin, 1994). Three publicly available sources of evidence are included in our analysis: companies' self-description, press release, business news.

## **4. Main Frameworks**

In this section, a set of basic frameworks is proposed to illustrate OOI practices. First, four common OOI practices are derived by introducing two dimensions for categorizing OOI. Second, OOI is positioned among three online mechanisms for external players to contribute value to firms. Third, there are three key business processes from the perspective of external innovators.

### **4.1 A Classification of OOI Practices**

There are four common OOI practices in consumer goods industries. The four practices are summarized into Table 1. The typical industries that apply each practice are listed in brackets. The practices could be classified according to the sources of innovation and intensity of interaction among external innovators. Customers and professionals are the two main innovation sources, and they correspond to customer-led practices and firm-led practices, respectively.

Table 1 The classification of OOI practices in consumer goods industry.

		Intensity of collaboration among external innovators	
		Collaborative practices	Non-collaborative practices
Sources of innovation	Customers	Open source goods (Consumer electronic, Automotive, Houseware)	2D/3D customization (Fashion, Photo printing, Houseware)
	Professionals	Ongoing contests (Fashion, Automobile, Consumer electronic)	Silent submission (Food, High-tech)

#### 4.1.1 Customization

Online customization companies allow customers to upload designs and purchase their designs. The companies print 2D photos or fabricate 3D objects for the customers. In addition, they sometimes also support customers to sell designs to other users.

#### 4.1.2 Open Source Goods

OSG usually opens the design of tangible goods based on Creative Commons license. OSG organizations allow individuals to design, purchase, assemble and sometimes sell tangible goods. Similar to the case of customization, on OSG platforms, an individual may act as a buyer, a designer, or take both roles. OSG organizations may be commercial or non-profit.

#### 4.1.3 Ongoing Contests

Ongoing contests allow external individuals to submit designs and vote on submitted designs. This practice could be applied in three contexts. First, for modular products which could be easily assembled (modular cars) or printed (T-shirts), the respective companies often promise to produce the winning designs and award the winners. Second, some established companies in electronic, IT and service industries hold idea contests, and turn the best ideas into reality. Third, some companies provide third-party platform for other organizations to hold contests. These platforms are called third-party contest services. The companies that have sporadic needs for contests could use such services.

#### 4.1.4 Silent Submission

The companies which adopt silent submission accept individual submissions, but usually don't have an online community (Crown, Kimberly-Clark). Although ideas are submitted silently, there could be some flexibility: some third-party contest services (FellowForce) allow clients to choose between accepting ideas openly and secretly. Silent submission involves three stages: submission, evaluation and commercialization. Companies may commercialize the best ideas by licensing, purchasing trademarks, or forming joint ventures or other alliances.

#### 4.2 Three Mechanisms of Contribution by External Subjects

There are three prevalent online mechanisms for external players to contribute value to firms: open innovation, crowd funding and collective decision-making. The latter two mechanisms are frequently integrated with open innovation, especially contests. These mechanisms may target at various levels (product, business, etc). Crowd funding allows external individuals to invest in a design or a designer. Collective decision-making allows external individuals to vote on designs, ideas or key business decisions. Although voting is the main tool for collective decision-making, comments are helpful for companies to make fine-tuned final choices. The framework that illustrates the three mechanisms is presented in Figure 1.

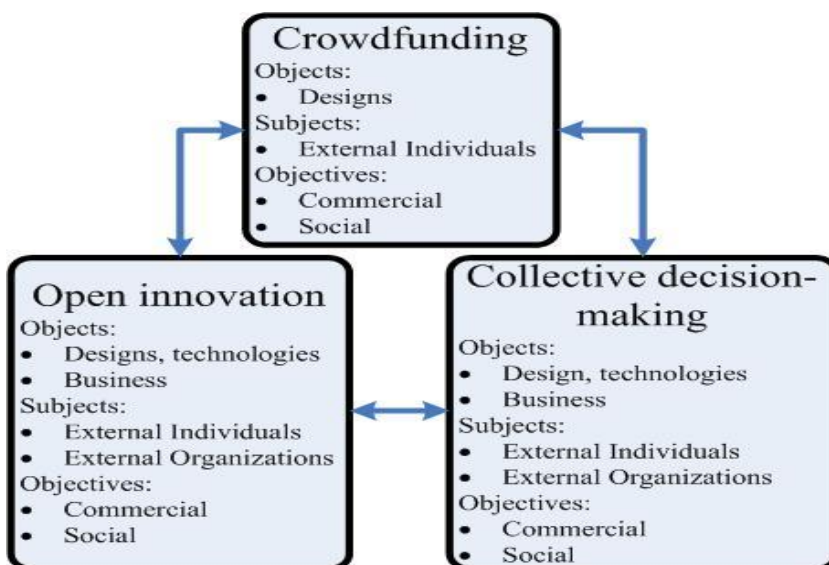


Figure 1: Three mechanisms for absorbing contributions from outside.

## 5. Influence of Product Complexity

In this section, by synthesizing cases, we derive some major evolution trends of OOI in consumer goods industries, and the impact of product complexity on these trends.

### 5.1 A Process Model from the Perspective of External Innovators

From the perspective of external innovators, there are three key business processes: design, production and selling (See Figure 2). This perspective is especially useful to customer-led OOI. We find that external innovators tend to implement the production and selling processes by themselves when product complexity and heterogeneity are high.

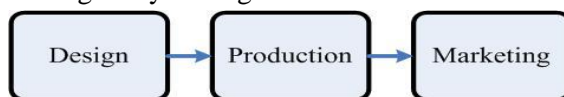


Figure 2: Three key business processes from the perspective of external innovators.

As external innovators become more and more important in product development and design, “self-marketing” becomes increasingly prevalent. We find that high product heterogeneity is generally related to high reliance on “self-marketing” – making marketing efforts by individual designers.

#### 5.1.1 Sales

Some customization companies support individuals’ selling process and conduct production. Sellers could own personal shop pages (Zazzle, CafePress, Lulu, Ponoko, etc). In contrast, very few OSG organizations have automated this process. Lego Factory is an exception, but that is because it has an easy-to-assembled and customizable set of modular parts.

#### 5.1.2 Pricing

Some customization companies allow sellers to control markups (Lulu, Spreadshirt, Wordans, Shapeways, etc). In general, companies tend to allow sellers to control markup when the product design is heterogeneous

#### 5.1.3 Production

For open source electronic hardware producers, design heterogeneity influences the likelihood the users make and sell hardware themselves. There are approximately five levels of freedom of making and selling, each corresponds to a certain level of design heterogeneity.

1. When software, schematics and CAD of a hardware device (VIA’s Openbook) are all being openly shared, individuals don’t have to purchase from

the focal organizations. Instead, they could revise the design, and then make and sell products themselves.

2. When a company sells a base product and keeps everything open (Arduino), the users could buy the base product, and then design, assemble, use and sell their own products.

3. When modular electronic producers sell a base product and modules simultaneously (Chumby, Bug Labs, Gumstix), their users could buy the base unit and various modules, revise the code, and use the assembled products, but they couldn't sell the products.

4. When companies sell integral products with open software (Neuros, iRobot, OpenMoko), users can only revise the code. Users couldn't sell products, since the software enhancements are shared openly.

5. When large companies sell integral products with "closed" operating systems, the application software development could be made open to external innovators (Apple's App Store, Nokia's Ovi Store).

## **5.2 Applied to products with higher tangibility**

OOI is increasingly applied to contexts with high tangibility. High tangibility is defined as high product complexity and heterogeneity. All the three mechanisms for external individuals to contribute to companies have shown this trend. Evidence is shown below.

1. Ongoing contest. First, Thread-less has been emulated by companies that produce more complex products (Local Motors, Dell's IdeaStorm). Second, companies that have already adopted contests are increasing the tangibility of the involved products. RYZ initially posts a different shoe template every month, and it plans to allow for varied shapes for each submission. It is also expanding into the market of technical athletic wear. Similarly, the parent company of Thread-less opened Naked, & Angry in order to apply contests to high-end clothing and house ware.

2. Customization. The customization companies that target at large-scale 3D objects (Physical Design) emerged later than companies that provide customization of small-scale 3D objects (Ponoko, Shapeways). The latter in turn emerged later than 2D customization companies.

## **5.3 Diffused From Information to Tangible Goods**

The above is about diffusing of OOI from low tangibility to high tangibility contexts. Below we present some evidence of the diffusing from information to tangible goods.

This trend is due to the fact that communication information doesn't require manufacturing capability. New practices of OOI were usually originally applied to intangible goods before they are applied to tangible goods. Tangible goods organizations that adopt OOI are often either inspired by or evolved from free design sharing websites (photo sharing websites, open source software communities).

The following are examples.

1. OSG. Open source philosophy is diffusing from software industry to consumer goods industries such as beers (Free Beer), houseware (Thingiverse, Ponoko), electronics (Neuros, Arduino), and vehicles (RiverSimple, Oscav, Local Motors). The founding of Free Beer (Raasch et al., 2009) and Riversimple were all inspired by the success of open source software.

2. Ongoing contest. Jake Nickell founded Threadless because he was unsatisfied with an online T-shirt design contest, which doesn't produce the winning designs.

## **5.4 More Interaction among External Innovators**

Facilitating communication among innovators is critical to innovation when the product is complex. There are two interaction formats among external innovators.

### **5.4.1 Online Community**

Open innovation practices could combine with an online community. In general, the platforms for commercial products which are complex and heterogeneous often enable users to seek help from online communities (e.g. Blurb) to improve their designs.

### **5.4.2 Teams**

By fostering close collaboration among external individuals, the diversity of external capabilities (knowledge and other resources) could be better leveraged. In a recent study, Raasch et al. (2009) find that OSG projects such as RepRap and Oscar tend to require developers to come from diverse backgrounds.

We find that the formation of teams on OOI platforms in high-tech industries is more common than in the industries where useful knowledge are widely dispersed among consumers and individuals (electronic, retail). In some scientific fields where knowledge is not widely diffused, companies (HP Labs, Nokia Research Center) mainly rely on collaborations with organizations such as research institutions, universities and start-ups. In contrast, Dell, Starbucks and Best buy don't support team formation on their open innovation platforms.



## **5.5 Leveraging the Capabilities of the Focal Company More Effectively**

Focal companies increasingly leverage and develop their capabilities that complement those of external innovators (technical expertise, reliable production, efficient distribution) when the submissions are complex. When innovators design complex and heterogeneous commercial products for themselves, they may even buy services from the companies (Lulu, Arduino) to improve their designs. Relevant cases mainly come from three industries. Most cases are from the industries with complex products.

1. Hardware industry. In Cisco's I-Prize annual competition, a full-time team initially filters the incoming ideas based on relevancy and impact on profit. Then the best ideas are assigned with mentors to help turn the ideas into workable business plans. Furthermore, the final winners are invited to be employed at Cisco.

2. Auto industry. Due to the high product complexity, design contests in automotive industry usually require extensive engagement of the focal organizations. While the online community crafts the exterior, Local Motors designs or selects the chassis, engine, and transmission – the elements that are critical to the cars' performance, safety, and manufacturability. Caterham gives its open source project Splitwheel access to its engineering resources, facilities and expertise to help turn the car into reality.

In Fiat Mio project, the best ideas are chosen and combined by a Fiat's own team. The team also tests the ideas and makes them viable. Similarly, in Peugeot Concours Design competition, 30 entries are selected by Peugeot, and then 10 entries remain after online voting. Next, Peugeot selects the top three. The winning design is then built by Peugeot.

## **5.6 First-Party Contests Versus Third-Party Contests**

Chaordix and CrowdSpirit both transformed from first-party to third-party contest platforms. This evolution is largely due to their incapability of implementing and commercializing complex and heterogeneous ideas.

## **5.7 Announcing Detailed Versus Broad List of Needs**

Silent submission companies that produce relatively simple products (Campbell, Nestle, Kellogg, etc) only announce a broad list of technological fields to innovators, while the silent submission companies that produce relatively complex products (GSK, Kraft, DSM, Sara Lee) dynamically update a detailed

list. Similarly, in auto industry, both Riversimple and OsCar specify problems and technical requirements for innovators. In contrast, OSG organizations in electronic industry don't provide such extensive specifications.

## 6. Conclusion and Implications

This present study aims to identify how product complexity and heterogeneity determine the evolution and diffusion of OOI practices in consumer goods industry. Firstly, the analysis of 138 cases led to re-conceptualization and further detailing of the open innovation framework. Instead of distinguishing between outside-in and inside-out processes, the present study proposes two new dimensions to categorize various OOI practices: sources of innovation and intensity of collaboration among external innovators. Then, based on this framework, the impact of product complexity and heterogeneity on online open innovation (OOI) practices is examined.

## References

- Chesbrough, H. (2006). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston, MA.
- Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&D Management*, 40(3), 311–316.
- Hansen, M., Nohria, N., & Tierney, T. (1999). *What's your strategy for managing knowledge?* Harvard Business School Press, Boston.
- Hienerth, C. (2006). The commercialization of user innovations: the development of the rodeo kayak industry. *R&D Management*, 36(3), 273–294.
- Moreau, C. P., & Herd, K. B. (2010). To each his own? How comparisons with others influence consumers' evaluations of their self-designed products. *Journal of Consumer Research*, 36(5), 806–819.
- Osterloh, M., & Rota, S. (2007). Open source software development—just another case of collective invention? *Research Policy*, 36(2), 157–171.
- Piller, F. T., & Walcher, D. (2006). Toolkits for idea competitions: a novel method to integrate users in new product development. *R&D Management*, 36(3), 307–318.

Pine, J. (1993). *Mass Customization – The New Frontier in Business Competition*. Harvard Business School Press, Boston, MA.

Pisano, G. P., & Verganti, R. (2008). Which kind of collaboration is right for you? *Harvard Business Review*, 86(12), 79–86.

Raasch, C., Herstatt, C., & Balka, K. (2009). On the open design of tangible goods. *R&D Management*, 39(4), 382–393.

Rigby, D., & Zook, C. (2002). Open-market innovation. *Harvard Business Review*, October, 80–89.

Sieg, J. H., Wallin, M. W., & von Krogh, G. (2010). Managerial challenges in open innovation: a study of innovation intermediation in chemical industry. *R&D Management*, 40(3), 281–291.

Stam, W. (2009). When does community participation enhance the performance of open source software companies? *Research Policy*, 38(8), 1288–1299.

Von Hippel, E., & von Krogh, G. (2006). Free revealing and the private-collective model for innovation incentives. *R&D management*, 36(3), 295–306.

Yin, R. *Case Study Research*. Sage, Thousand Oaks, CA, 2nd ed.

Zollo, M., & Winter, S. G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science*, 13(3), 39–51.