The Dilemma of Design Innovation: Analysis of Mobile Phone’s Design Patent

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Abstract: Eisenman (2013) argues that the importance of design innovation increases in the early and late stages of an industry and is lowest in the middle stage. In response, this study empirically examines her proposition through an examination of mobile phones during the feature phone era (1999–2008) when various types of designs were being generated using design patent data. We analyze the number of mobile phone design patents registered before the current advent of smart phones as well as examining the yearly averages of forward citations (the number of times a particular design patent is cited in later design patents) and backward citations (the number of times a particular design patent cites previous design patents). Further, to shed light on

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interactions with an accumulation of design-related technology, the study also analyzes the number of design-related patent applications per year. Results reveal that while there was an increase in the number of design patents registered in the late stage of the industry, especially between the years of 2007–2008, the average number of forward citations drops below the average number of backward citations from 2003 onward. In other words, although at the late stages of the industry many design innovations emerged, most of these were incremental changes that followed past designs. In contrast, design-related patent applications reached a peak in 2004 and fell thereafter. It is hypothesized that this trend was influenced by the growing number of design-related patents that facilitated the easy generation of new variations in design. These results show the dilemma: Although design innovations continue to be generated over time by accumulating design-related technology, creating genuinely impactful design innovation becomes more difficult as time progresses. The study therefore demonstrates the difficulty of realizing Eisenman (2013)’s theoretical proposition.

Keywords: design innovation, design patent, mobile phone, patent

Introduction

Dynamic change in innovation is discussed as a central theme of innovation research (Abernathy, 1978; Abernathy & Utterback, 1978; Utterback & Abernathy, 1975). In recent years, design innovation is discussed from a dynamic perspective (e.g., Eisenman, 2013, 2017). According to Eisenman (2013), the importance of design innovation increases in the early and late stages of an industry, and is lowest in its middle stage. This study attempts to analyze these findings using design patents and design-related patents. Results indicate that while design-related technology continued to accumulate in the late stages of the mobile phone industry and gave
rise to many design innovations, most of these changes were incremental adjustments to past designs. The composition of this study is as follows: Section 2 overviews prior research and suggests the subject of analysis in this study. Section 3 describes the method of analysis used, then shows the results of this analysis. Section 4 presents a discussion based on these results.

Dynamic Change of Design Innovation

There has been increasing attention paid (e.g., Akiike & Yoshioka-Kobayashi, 2017; Bornemann, Schöler, & Homburg, 2015; Homburg, Schwemmle, & Kuehnl, 2015; Rubera & Droge, 2013) to the industrial designs of products (e.g., Dumas & Mintzberg, 1991; Gemser, Jacobs, & Cate, 2006). In addition, design innovation dynamics are also drawing attention (e.g., Cappetta, Cillo, & Ponti, 2006; Eisenman, 2013; Walsh, 1996). Eisenman (2013) discusses the dynamic change in importance of aesthetic innovation over time. Based on Eisenman (2013), the importance of aesthetic innovation increases in the early and late stages of an industry and is lowest in its middle stage. To demonstrate this point, Eisenman (2017) conducted content analysis of the computer industry and

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1 The idea that importance falls temporarily in the middle stages of an industry is also consistent with Walsh (1996) and Cappetta et al. (2006). Walsh (1996) focuses on the relationship between industry stages and the role played by design. Walsh (1996) stated that the role of design in the initial stages of an industry are experimentation and technological innovation, while in the middle stages design’s focus switches to ensuring ease of production. In later stages, design’s role shifts to fashion and the generation of variety (Walsh, 1996). Furthermore, Cappetta et al. (2006) state that in fine fashion between 1984 and 2002, the three styles of masculine, minimal, and kitsch repeatedly cycle between positions of ferment (divergent) and convergence (incremental). In other words, they show that after various designs are explored in the initial stage, there is convergence within the industry, followed once again by the exploration of new designs.
points out that, after the entry of the iMac (1999–2003), product reviews and other discourse about personal computers began to focus increasingly on aesthetics.

Eisenman (2013) proposed a theoretical model, and her subsequent work empirically investigated the model using the PC industry as the subject of analysis but focuses on elements such as product reviews (Eisenman, 2017). However, there is insufficient consideration given to the frequency of design innovations themselves or their impact, as well as to the interaction with technologies, specifically those that have realized novel aesthetics. Innovations in design-related technology are also critical in realizing a design (e.g., Akiike & Yoshioka-Kobayashi, 2015; Morinaga, 2017). In particular, designs incorporating new aesthetic characteristics often call for new raw materials, structure, parts and manufacturing processes. In some cases, the design cannot be realized without these supporting technologies. For example, Akiike and Yoshioka-Kobayashi (2015) analyze the development process of a compact digital camera with a unique design allowing for free rotation of a part of the body, the design called for mechanical restructuring of the body and molding technology. However, Eisenman (2013, 2017) does not adequately consider investigating from this perspective. Therefore, this study aims to analyze the generation of design innovations and the dynamic changes of their impact from the perspective of design-related technology.

Method

The subject of analysis in this study is the Japanese mobile phone industry. Its context fits well with the examination of our research question as they experienced both prosperity and decline. Typically, unlike the current age of homogenous smartphones, a wide range of diverse designs were generated during the period when feature
phones were mainstream (1998–2008) (e.g., Akiike, 2017), particularly after 1999 when the world’s first cellular Internet connection service (“i-mode”) started. The service gave rise to significant simultaneous changes in function and design (e.g., Akiike, 2017; Akiike & Katsumata, 2018). Because of this, design innovation can be analyzed from a dynamic perspective through the course of the history of the mobile phone industry. The analysis uses design patents and design-related patents. Examining patent data is an effective method of analyzing dynamic innovation activity (Brem, Nylund, & Schuster, 2016), and this study extends this knowledge to design patents.

Design patents that included the words “mobile phone” or equivalent words and phrases in the subject matter were selected from the “Survey of Trends in Design Patent Applications” (Japan Patent Office, 2012). Design patents gathered in this way were organized by year from 1999 to 2008 based on their registration date. This study uses both forward citations and backward citations of design patents. Forward citations indicate the number of times that a design patent is cited in later design patents. Based on these forward citations, we can grasp the level of influence that a patent

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2 The transition of feature phone design is described by Akiike (2017).
3 Design patents are used as representative indicators of design innovation in existing research (Dan, Spaid, & Noble, 2018; Rubera & Droge, 2013). It is also common for products that win a design award to be registered as a design patent (Yoshioka-Kobayashi, Fujimoto, & Akiike, 2018).
4 Mobile phone design patents and other patents were gathered from PatentSQUARE https://www.panasonic.com/jp/business/its/patentsquare.html
5 Patents that included synonyms for “mobile phone” such as keitai denwa, keitaiyō denwaki, keitai denwaki in the subject matter were selected (excluding musen denwaki, “cordless telephone”). Design patents that were not focused on the mobile phone itself were excluded. This analysis only targets entire designs in which the whole product design is registered (Figure 1).
6 The registration date is assumed to be close to the time when a product using the design goes to market.
has had on later designs. On the other hand, backward citations indicate the number of past design patents cited by a design patent. These backward citations imply how much a patent was influenced by previous designs.\(^7\) This study calculates the average number of forward citations and backward citations in design patents registered in each year.\(^8\)

Next, this study examines design-related technology. According to

\(^7\) It is necessary to note that citations are based on the judgment of the patent examiner. The problem of truncation is addressed in data up until design patents registered by end of year 2017. Additionally, co-citations are excluded from forward citations.

\(^8\) A couple of design patents lack backward and forward citation data due to minor errors in the original database. While these design patents are included in the number of registered patents, they are excluded from the calculation of averages.
existing research, technology is developed and utilized as a knowledge base for future innovations (e.g., Breschi, Lissoni, & Malerba, 2003; George, Kotha, & Zheng, 2008; Kauffman, Lobo, & Macready, 2000). The generation and accumulation of design-related technology makes possible further generation of designs with various forms (e.g., Akiike & Yoshioka-Kobayashi, 2015; Morinaga, 2017). The design-related patent applications from 1985 to 2008 were analyzed in order to incorporate design-related technology into the knowledge base.9

Using similar methodology as “Survey of Trends in Design Patent Applications” (Japan Patent Office, 2012), design-related patents that included technology that concerned the appearance of mobile phone devices in the patent document were collated.10 These patents were then sorted according to innovations in design aesthetics, structure, and material of the mobile phone device, based on the International Patent Classification (IPC) granted to each patent.11 Design-related patents retrieved in this manner were then aggregated by year from 1985–2008, based on their application dates.

Results

Results revealed an increasing trend in the number of mobile

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9 We adopted application dates as the time of new technological knowledge accumulation.
10 Specifically, patents that include documents on the body, structure, style, or design and aesthetics as well as “mobile phone” or equivalent terms.
11 Patents were counted when over 20% of the IPC granted to a patent corresponded to “Audio-visual technology,” “Telecommunications,” “Optics,” “Macromolecular chemistry, polymers,” “Basic materials chemistry,” “Materials, metallurgy,” “Surface technology, coating,” and “Mechanical elements” when checking them against the World Intellectual Property Organization’s IPC and Technology Concordance Table (https://www.wipo.int/meetings/en/doc_details.jsp?doc_id=117672). These standards were formulated by reading the abstracts of randomly extracted patents and selecting the most frequent categories.
**Figure 2.** Transition of design patent

*Note:* This data is based on registration date.

*Source:* PatentSQUARE

**Figure 3.** Transition of forward and backward citation

*Note:* This data is based on registration date.

*Source:* PatentSQUARE
phone design patents registered in the later stages of the industry, especially between the years of 2007–2008 (Figure 2). Based on year-by-year changes in the average number of forward citations and backward citations, this implies that there were more forward citations than there were backward citations on average until 2003. However, this trend reverses after 2003 (Figure 3). Whereas forward citations reached a peak in 2004 before sharply declining, backward citations show high averages until 2006. The change in the number of design-related patent applications over time was also observed, reaching a peak in 2004, then showing a decreasing trend (Figure 4).

**Discussion**

Eisenman (2013) asserts that the importance of design increases in the early and late stages of an industry. Our results are partly
consistent with her argument. In the early stage of mobile phone industry, while design patent applications were relatively few, average forward citations exceeded average backward citations.

However, the results of this study differ from Eisenman’s findings for the industry’s later stages. Figure 2 displays a sharp increase in activity regarding the number of design innovations generated in the industry’s later stages. It can be hypothesized that this occurred because enough design-related technologies had accumulated by 2004 (Figure 4) to heighten design versatility (Abernathy & Clark, 1985) and facilitate the generation of new designs. However, Figure 3 illustrates the dramatic growth of the average number of backward citations from 2002 onward, and a reverse trend in the average number of forward citations. The average number of backward citations drops in 2007–2008 but is still higher than the average number of forward citations. From these results, it can be seen that the impact of design innovation in the industry’s later stages was mostly incremental. In other words, based on this study’s results, design innovation in the later stages of the industry increased due to gains in design-related technology, but most of these innovations were incremental changes that were influenced by past designs. The discovery of this fact is this study’s main contribution to Eisenman (2013). Businesses may also seek new means of design innovation to ensure their continued survival. However, our empirical analysis shows that, in reality, generating a socially high-impact design innovation is not so feasible.

Despite product innovation occurring frequently in the early stages of an industry, as a dominant design becomes established, process innovation becomes increasingly mainstream, fixed, and incremental. Abernathy (1978) calls this phenomenon the

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12 In Akiike (2014)’s analysis of the mobile phone industry, restrictions placed on design by functional elements were eliminated from 2008 onward. The analysis results of this study are consistent with this fact.
“productivity dilemma.” Based on this argument, Ikuine (2011) points out that the video game industry confronted a development productivity dilemma in their matured stage: Video game developers committed to the development of titles that are low in newness at the expense of developing games that are high in newness. Similarly, in the realm of design innovation, there is the potential for reaching a productivity dilemma in which new design variations are generated without accompanying essential changes.

The discovery of this phenomenon can be said to form the basis of this study’s contribution to theory and methodology. However, several issues remain with this study. Primarily, the analysis was a descriptive statistical analysis and future research will require more rigorous analysis. In addition, analysis of industries other than the mobile phone industry is necessary. Further accumulation of research in design innovation is anticipated in the future.

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References


Eisenman, M. (2017). A multimodal investigation of the institutionalization of aesthetic design as a dimension of competition in the PC industry. In M. Höllerer, T. Daudigeosand, & D. Jancsary (Eds.), *Multimodality, meaning, and institutions* (pp. 183–217). Bingley, UK: Emerald.


