Organizational Factors in the Product Design Development Process

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Abstract

The purpose of this study is to identify management requirements for creating more highly advanced and innovative designs. This study focuses on ways to involve design divisions in the product development process as well as organizational requirements that impact that process by evaluating the results of existing design management research and analyzing survey results of recipients of Japan's Good Design Award. In this analysis we show that having design divisions involved from an early stage contributes to the overall product development process, and separately preparing for organizational factors in design development is insufficient to create highly advanced and innovative designs. Further, we examined the impact of organizational factors related to design development on the contribution of design divisions in developing highly advanced and innovative designs.

Keywords: design management, product design development peocess, organizational factors, design devision

1. Introduction

The purpose of this study is to identify management requirements for the creation of more highly advanced and innovative designs that contribute to a corporation's competitive advantage and fundamental differentiation. In today's mature markets, it is difficult to differentiate the fundamental products of a manufacturing firm based on sufficient functionality, consistent quality, and low prices. Rather, differentiation requires a firm to look beyond these elements. Thus, technology-focused traditional studies on product development management alone are not adequate in answering the problems faced by today's manufacturers. Recent years have seen a growing realization of the importance of product and business development that understands design to be an important management resource (Borja de Mozota, 2003; Utterback et al., 2006). Existing studies have shown that a focus on design leads to competitive advantage and better corporate results (Walsh & Roy, 1985; Black & Baker, 1988; Walsh, Roy & Bruce, 1988; Hart, Service & Baker, 1989; Yamamoto & Lambert, 1994; Walsh, 1996; Gemser & Leenders, 2001; Hertenstein, Platt & Brown, 2001; Borja de Mozota, 2003; Hertenstein, Platt & Veryzer, 2005; Talke et al., 2009).

Research on design management within management studies began in the latter half of the 1980s. However, the results of these studies could never sufficiently answer the most important and fundamental question, "How should companies manage organizations and development processes to create superior designs which contribute to fundamental differentiation and competitive advantage?" This study focuses on the contributions made by design divisions in the product development process and their organizational factors as we examine effective management for developing highly advanced and innovative designs.

Further, "design" as defined in this study is primarily product design, and refers to the results of a series of activities to generate ideas and concepts, and then to realize them. In addition, "highly advanced and innovative" as used herein refers to design that creates heretofore non-existing concepts and expressions or creates news users and markets. "Highly advanced and innovative" design qualities, which are the resulting variables of this study, are those that result in fundamental differentiation from and competitive advantage over the products of competitors (Talke et al., 2009). In addition, they contribute to corporate results (particularly for products in mature markets) (Gemser & Leenders, 2001). This is because blasé design makes it difficult for companies to create a product image and corporate brand (Morinaga, 2010).

2. Considering Existing Studies

2.1 Inter-Division Coordination in the Design Development Process

Most existing design management research assumes that "design is important to corporate management" and answers the question of "what kind of management is required to effectively generate superior design?"

In recent years, the importance of the function and domain of design in a broad sense has been noted, and design has come to be seen as an activity that creates products and concepts, and not merely something that coordinates product shapes and colors. Walsh and Roy (1985) and Roy and Riedel (1997) defined design function and domain in this broad sense, and showed that companies that proactively involve themselves in the product development work of the design division have better corporate results (sales growth, etc.) than companies that do not.

In the broad sense of the function and domain of design, the areas where design divisions are involved in the product development process extend upstream as well as downstream in that process. However, when design divisions are involved both upstream and downstream of the product development process, the amount of knowledge and information processed between design divisions and other divisions increases when product development activities are understood to be a process of transferring and integrating knowledge and information (Womack, Jones & Roos, 1990; Clark & Fujimoto, 1991). In particular, when one considers design activities themselves to be the realization of knowledge and information that it has created, and the forming of these into a specific form (Utterback et al., 2006), it is more effective to closely coordinate design development activities between design divisions and other divisions (e.g. marketing, sales, manufacturing and production, R&D, etc.) rather than to transfer and integrate the increasing knowledge (Kotler & Rath, 1984; Gorb & Dumas, 1987; Roy & Potter, 1993; Olson, Slater & Cooper, 2000; Bruce & Daly, 2007).

Existing design management research includes studies that focus on inter-division coordination between design and other divisions based on the characteristics of design development activities. For example, Walsh, Roy and Bruce (1988) note the importance of the amount of overlap in those involved in the design development processes and the closeness of the communication between design and other divisions. Dumas (1995) points out that cross-functional groups involved in design must go through complex processes to integrate knowledge in order to create great designs in organizations involving members from various divisions. Dickson et al. (1995) and Gregory and Sohal (2002) assert that cross-functional organization management in design makes it possible to discover new designs and ideas, clearly differentiate with competitors, and innovate. Bailetti, Callahan and McCluskey (1998) point out that coordination among interdependent divisions affects productivity and performance in design and other divisions, and the importance of strengthening relationships between members of design and other divisions, and the importance of creating frameworks to efficiently transmit information and knowledge to designers regarding corporate goals, priorities, and design strategies, as well as processes that encourage effective communication, discussion, and participation.

These studies all point out that coordination between cross-functional and interdependent groups in the product development process impacts knowledge integration, information transfer and sharing, and design development effectiveness. It is these factors that affect final design results.

2.2 Involvement of the Design Division in the Design Development Process

Based on the characteristics of this kind of design process, arguments have gone back and forth on whether the involvement of design divisions in the product development process improves the end results of design. For example, Bailetti and Guild (1991) focused on the depth of designer knowledge and diversity of background, and stressed the importance of design division involvement from an early stage of product planning in the product development process in order to develop innovative new products. Walsh and Roy (1985) showed that companies with excellent performance have design divisions linked to marketing, manufacturing and production, and other divisions from early stages in product development. These researchers also point out that the design divisions in these companies are in a position to consider all sorts of elements relating to product development, and act as gatekeepers. Lorenz (1990) also showed that products where designers act as informal product planners or project leaders are successful, and noted that designers should be given roles where they can make connections in the product development process or the formation of marketing strategy. In other words, designers are not merely stylists or providers of ideas, but must have the capacity to integrate and coordinate product development processes.

A common element in these arguments is the suggestion that achieving high performance in the creation of superior design requires the participation of design divisions from an early stage in the product development

process and having them act as the main drivers in integrating product development activities in order to skillfully work with other groups in the creation of superior design and efficient product development.

In addition, these studies also all agree that designers must not be treated as mere engineers or architects, but as "gatekeepers" for knowledge and information both internal and external to the organization. In addition, they have the characteristic of being "connectors" mediating between marketing, engineering, and design divisions, and "integrators" as they involve themselves in the overall product development process and compile knowledge and information in moving towards their final goal.

These studies all show that the total involvement of the design division as central players in the product development process is critical to a corporation's creation of highly advanced and innovative designs.

2.3 Organizational Factors in the Design Development Process

Some existing research discusses management requirements for creating superior designs from the perspective of the relationship between overall corporate management strategy and design strategy. For example, Dumas and Mintzberg (1989) argues that, in addition to making design a part of management strategy, design functions, policies, and programs must be put in place and executed in line with that strategy in order to create unique designs that differentiate from competitors. In addition, Borja de Mozota (1998) use the "value chain" framework of Porter (1985) to incorporate design into overall management strategy and link the integration of corporate value chain elements to high design performance. When it is understood that design is the realization of product concepts and corporate management principles (Borja de Mozota, 2003), then it can be seen that executing a corporate design strategy carries significance from the corporate perspective.

There have also been discussions regarding organizational structure design to effectively put in place corporate management strategies for design and inter-departmental coordination as described above (Morinaga, 2005, 20010; Kanno, 2011). These discussions revolve around the decentralization of design divisions with the intent of giving these design divisions greater authority, creating an environment to mitigate the impact of engineering and other divisions, and making it easier for design divisions to lead the execution of corporate design strategy. Highly self-sufficient organizations, such as a divisional organization, tend to emphasize short-term results and efficiency (Chandler, 1962; Galbraith, 1972; Galbraith, 2002). In doing so, design becomes bland due to limits placed on the use of designer knowledge and capabilities, and there is a heightened risk of design activities becoming fragmented and scattered by project or product area. With this in mind, Morinaga (2005, 2010) argues for the necessity of creating an organizational framework that will reduce and absorb costs that rise due to information processing and coordination brought about by decentralization. Kanno (2011) notes that simply separating design groups from business units and making them independent are not enough to change communication patterns with other divisions; an organizational framework that leverages the leadership and independence of the design divisions is also necessary, in regard to authority areas such as budgeting or human resources.

There have also been studies on decision-making in regard to design. Owen (2000) points out that differences in status among members involved in design development exert a large and decisive impact on design results. Chiva-Gomez (2004) states that having the participation of a variety of members is important to design-related decision-making and that it is also important to keep in mind the power balance between these members. Morinaga (2008) conducted research on the relationship between decision-making styles in the design development process and the type of design strategy, and identified the extent to which decision-making frequency, team member variety and numbers, and decision-making standards impact design results. These studies show that the individuals making design-related decisions and their decision-making process ultimately have important effects on the design results.

3. Analytical Framework

As can be seen from the above, existing research clarifies various management requirements in creating highly advanced and innovative designs, but also leaves other issues unanswered.

Existing studies go no further than showing various factors such as the consistent involvement of design divisions in the overall process; mutual coordination between design and other divisions; the priority of design strategy in overall management strategy; organizational structure; decision-making methods; etc. No study discusses the relationships between these factors. When one considers that a design goes through multiple divisions in a complicated process before being consolidated into one form (Dumas, 1995), one can see the need to identify how ultimate design results are impacted by mutual relationships between various organizational factors, rather than focusing on each factor separately.

We created an analytical framework for this study incorporating the six factors above: the consistent involvement of design divisions from an early stage in the overall process; coordination between design and other divisions; the overall design strategy; overall organizational structure integrated with design; decision-making methods; and human resources authority in the design department (Figure 1).



Figure 1. Analytical framework

First, individual organizational factors relating to design development are structured such that they affect the advanced nature and innovativeness of a design by themselves. The importance of these individual organizational factors has been noted within existing studies. Therefore, in this study we will analyze the individual impact of these various factors on the advanced nature and innovativeness of designs.

At the same time, one thing we do know from existing research is that the total involvement of design divisions from an early stage in the product development process is essential for the creation of highly advanced and innovative designs (Walsh & Roy, 1985; Lorenz, 1990; Bailetti & Guild, 1991). These studies assume a direct relationship between design division involvement and design results because design personnel are deeply involved across the entire product development process. Thus, we will analyze the impact on the advanced nature and innovativeness of designs of this consistent involvement of design divisions from an early stage in the product development process.

On the other hand, actual design development processes are carried out within various organizational contexts, such as internal corporate strategy, organization structure, inter-divisional coordination, decision-making, etc. It is therefore necessary to consider the impact of design division involvement on design results based on the effect of these various factors. Accordingly, this study is structured such that the consistent involvement of design divisions from an early stage impacts the advanced nature and innovativeness of design affected by organizational factors such as inter-divisional coordination methods as well as the presence or absence of a corporate design strategy, overall organizational structure integrated with design, and human resources authority in the design department.

One analytical method that considers these sorts of organizational factors is an analysis of interactions. When interactions are assumed to exert a certain influence, the effect of the impact of variables of interest can be analyzed. In other words, it becomes possible to analyze the effect of design division involvement in the product development process by considering organizational factors. Accordingly, this can be verified quantitatively by testing the effects on our model of interactions between organizational factors and the involvement of design divisions from an early stage. The hypotheses used in this study are listed in Table 1, with arrows depicting causal relationships in Figure 1.

Table 1	l. Hypotheses
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No.	hypotheses
Hypothesis 1	The involvement of design divisions from an early stage by itself does not impact the advanced nature and innovativeness of designs.
Hypothesis 2	The setting of corporate-wide design strategy does not by itself impact the advanced nature and innovativeness of designs.
Hypothesis 3	Inter-division coordination prioritizing the design division's intent does not by itself impact the advanced nature and innovativeness of designs.
Hypothesis 4	The creation of a corporate-wide design integration team does not by itself impact the advanced nature and innovativeness of designs.
Hypothesis 5	Ultimate design-related decision-making by design divisions does not by itself impact the advanced nature and innovativeness of designs.
Hypothesis 6	Design divisions having HR authority over designers does not by itself impact the advanced nature and innovativeness of designs.
Hypothesis 7	When there is a corporate-wide design strategy, involvement of the design division has a positive impact on the advanced nature and innovativeness of designs.
Hypothesis 8	When design division intent is prioritized in inter-division coordination, involvement of the design division has a positive impact on the advanced nature and innovativeness of designs.
Hypothesis 9	When there is a corporate-wide integration division, involvement of the design division has a positive impact on the advanced nature and innovativeness of designs.
Hypothesis 10	When the design division is the ultimate decision-maker in regard to design, the involvement of the design division has a positive impact on the advanced nature and innovativeness of designs.
Hypothesis 11	When the design division has HR authority over designers, involvement from the design division has a positive impact on the advanced nature and innovativeness of designs.

4. Survey Overview

4.1 Survey Method

"Design Management Research" and an accompanying design management survey were conducted for this study to research the impact of various organizational factors on the advanced nature and innovativeness of designs. The survey was conducted from March 2012, with cooperation from 40 companies out of a total of 141 manufacturers that had established internal design divisions and received Japan's Good Design award in the prior two years (2010 and 2011).

Companies targeted for the survey were manufacturers of automobiles, appliances, office automation equipment, furniture, and daily living items. Recipients of the Good Design award were targeted in particular because of an assumed awareness of design management, and because they had been recognized by other experts for their designs. The Good Design award screens for things such as originality, functionality, attractiveness, freshness, superiority in concept, and innovation, precisely the design results established for this study. In addition, because our respondents were all Good Design award recipients, the likelihood of achieving more accurate data and analysis was increased.

On the other hand, there is the demerit of having a smaller number of respondents, but the negative aspects of a small sample size can be mitigated by using a Bayesian model for estimation. Bayesian models make it possible to conduct a rational analysis on small datasets using past knowledge on a prior probability distribution. An informed prior was used for this study, using similar research and extant coefficient parameters derived from beliefs held by experts.

4.2 Explanation of Date and Variables

The importance of consistent involvement by design divisions from an early stage in the product development process has been identified as a primary factor impacting advanced and innovative design (Walsh & Roy, 1985; Lorenz, 1990; Bailetti & Guild, 1991). In particular, highly advanced and innovative design can be most

expected where design divisions take the lead in corporate-wide design management. This study is based on subjective evaluations by designers regarding the advanced nature and innovativeness of their companies' products. Specifically, we asked questions about corporate design to managers or designers in design divisions.

Three questions were asked: "Are your company's designs innovative?"; "Do you feel many of your company's designs are fresh and new?" and "Do you feel your company's designs are unique and differentiated from other companies?" Responses were given on a seven point Likert scale.

Analysis of the responses was done comprehensively, with data created to show the presence or absence of advanced and innovative design. Further, this data was processed using the seven point Likert scale as a basis for distinguishing this presence or absence, with a 1 indicating a response of "company designs are definitely advanced and innovative," "strongly applicable," or "applicable," with all other responses being set to 0.

Variables for organizational factors related to design were specified by the following questions. The presence or absence of corporate-wide design strategy was inquired about with the question, "Is design regarded as a part of corporate strategy?" Inter-divisional coordination was inquired about with the question, "In the event of conflicts between divisions in negotiations for designs decisions, what kind of style is used to resolve the conflicts and build consensus?" in order to find out whether the intentions of the design division carry more weight in the event of conflicts. The presence or absence of a corporate-wide division overseeing design was inquired about with the question, "Does your company have a division dedicated to consolidating design at a corporate level?" In regard to decision-making we asked the question, "Who makes the ultimate decisions regarding designs for major products?" to determine whether design divisions make these decisions. In regard to HR authority in the design division determines assessments. Personnel assessments were inquired about with the question, "Does the design division state the design division determines assessments. Personnel assessments were inquired about with the question, "Does the design division have authority in personnel decisions?"

4.3 Date Summary

We multiplied the data compiled using the above methods by the average variance of the data as interaction terms to see the impact of organizational factors and the involvement of design divisions on highly advanced and innovative design. The Summary statistics of the data are shown in Figure 3.

First, the Summary statistics shown are variables for average, standard deviations, minimum values, maximum values, and data ranges. Pre-processed variables are described for advanced and innovative design, design division involvement, corporate-wide design strategy, inter-division coordination, corporate-wide design organizations, decision-making, and design division HR authority. Post-processed data for each are used for interaction terms in our analysis. One can confirm from the data that there are no unusual values for averages, standard deviations, and ranges (Table 2).

	average values	standard deviations	minimum values	maximum values	data ranges
advanced nature and innovativeness of design	4.82	1.31	3.00	7.00	4.00
design division involvement	1.62	.92	1.00	4.00	3.00
corporate-wide design strategy	.74	.45	.00	1.00	1.00
inter-division coordination	.38	.49	.00	1.00	1.00
corporate-wide design integration team	.56	.50	.00	1.00	1.00
design-related decision-making	1.50	.71	.00	2.00	2.00
human resources authority in the design department	.62	.49	.00	1.00	1.00
design division involvement $ imes$ corporate-wide design strategy	13	.48	-1.76	.46	2.22
design division involvement \times inter-devision coordination	15	.38	90	.86	1.76
design division involvement \times corporate-wide design integration team	08	.46	-1.33	.61	1.94
design division involvement \times design-related decision-making	12	.44	86	.90	1.76
design division involvement $ imes$ human resources authority in the design department	13	.68	-2.07	1.19	3.26

Table 2. Summary statistics

5. Analysis

Our analysis was conducted by creating three models for comparison in order to assess their appropriateness in considering interactions: Model 1, which focused on individual effects; Model 2, which focused on interaction effects; and Model 3, which considered both single and interaction effects.

The model selection criterion DIC was used for model comparisons. DIC is one standard measure for

information criterion, with lower values indicating a superior model. As a result of comparing models with this measure, we found Model 3 to have the lowest DIC, making it the most superior model. This shows that considering both single and interaction effects makes for the best model, and that considering interactions is an effective method to use in an organizational analysis (Table 3).

Table 3. Analysis result

	model 1	model 2	model 3	
	confficient	confficient	confficient	
design division involvement	0.66 ***	0.08	0.11	
corporate-wide design strategy	0.29		0.21	
inter-division coordination	0.40		0.30	
corporate-wide design integration team	0.27		0.11	
design-related decision-making	0.22		0.20	
human resources authority in the design department	-0.19		0.02	
design division involvement \times corporate-wide design strategy		0.56 **	0.68 ***	
design division involvement \times inter-devision coodination		0.78 ***	0.82 ***	
design division involvement \times corporate-wide design integration team		0.70 ***	0.74 ***	
design division involvement \times design-related decision-making		0.51 **	0.63 ***	
design division involvement \times human resources authority in the design department		-0.24	-0.26	
DIC	43.20	44.45	42.21	

Accordingly, we interpret coefficients resulting from Model 3 as follows. In Model 3, coefficients for design division involvement, corporate-wide design strategy, inter-division coordination, corporate-wide design organizations, decision-making, and design division HR authority were all shown to be not significant for single effects. On the other hand, the coefficients for interactions were shown to be significant for all but design division HR authority.

In other words, organizational factors impacting design development noted in existing research, such as corporate-wide design strategy (Borja de Mozota, 1998; Dumas & Mintzberg, 1989), inter-division coordination (Walsh, Roy & Bruce, 1988; Dickson, et al., 1995; Dumas, 1995; Bailetti, Callahan & McCluskey, 1998; Gregoly & Sohal, 2002; Chiva-Gomez, 2004), organization structure (Morinaga, 2005, 2010; Kanno, 2011), and decision-making (Owen, 2000; Chiva-Gomez, 2004; Morinaga, 2008) were all shown to have no positive impact by themselves on achieving highly advanced and innovative design. From these results, we can see that having these organizational factors in design development by themselves is not sufficient to create highly advanced and innovative design. In other words, creating highly advanced and innovative design requires integrated management of related organizational factors.

In addition, the early and consistent involvement of design divisions in the product development process, the particular focus of this study, was shown to not improve the advanced nature and innovativeness of designs in and of itself. Existing research (Walsh & Roy, 1985; Lorenz, 1990; Bailetti & Guild, 1991) emphasizes that the early-stage involvement of design divisions in the product development process allows these design divisions to function as the integrator of the product development processes, allowing for good inter-division coordination and, as a result, the creation of optimal designs. In response to that assertion, the results of this study show that from the early-stage, consistent involvement of design divisions alone is not sufficient. This implies that, despite the involvement of design divisions in upstream product development processes, other organizational factors such as inter-divisional power relationships and decision-making structures give rise to unintentional design changes and compromises as seen by the design division. This seems to result in risks to advanced and innovative design creation.

From the above, we can see the importance of proactively engaging design divisions in product development, and the creation of some type of organizational framework or system that leverages the design division as "gatekeepers," "connectors," and "integrators." Also, the data suggest the need to examine other organizational factors to see whether or not there is a relationship with design division involvement and an impact on design results. Below we will interpret each coefficient based on the results of our analysis, and consider the implications in detail.

5.1 Design Devision Involvement × Corporate- Wide Design Strategy

First, our results showed an improvement in advanced and innovative design with consistent involvement of the design division from an early stage, in companies where design is understood to be part of overall corporate management strategy.

The results of our analysis are consistent with the existing research of Dumas and Mintzberg (1989) and Borja de Mozota (1998). By positioning design strategy within corporate management strategy, corporate consensus around design, inter-division understanding, and cooperation can be achieved, with consistent development of highly advanced and innovative design becoming possible.

Positioning design strategy within corporate-wide management strategy means involving top management in design, and shows management takes responsibility for design. With top management positioning design strategy from a corporate perspective, execution of design strategy becomes consistent and the involvement of design divisions in the product development processes from an early stage is given more legitimacy. As a result, consistent design development by the design division becomes possible, and the creation of highly advanced and innovative design can be expected.

It is also necessary to clearly show the importance of design strategy, and the design division as its standard bearer, by internal organizational structures and decision-making systems such as functionally differentiating the design division and placing them under direct control of management, as well as strengthening the authority of the division.

5.2 Design Division Involvement × Inter-Divisional Coordination

Second, our results show that, in the event of inter-divisional conflicts, design becomes more advanced and innovative with the consistent involvement of design divisions from an early stage when inter-divisional coordination is promoted with priority given to the intentions of the design division.

The results of this study suggest that coordination prioritizing the intentions of the design division, without excess influence from other divisions, is optimal for the creation of highly advanced and innovative designs.

Conflicts between design and other divisions may arise in each step of the product development process, such as creating actual product specifications and implementing manufacturing plans (Kanno, 2011). This is due to problems such as production costs clearly growing higher than planned with the initial design as the product development process moves forward or with traditional production technology being unable to respond. In these situations, if the engineering or manufacturing divisions have relatively more power than the design division, for example, the possibility increases for the intentions of the engineering or manufacturing divisions to be pushed through, where cost and productivity are paramount. As a result, aspects of advanced and innovative design are lost as the end product is finalized.

Prioritizing the intentions of the design division at the expense of cost and productivity is not necessarily required in all aspects of design. However, it can at least be said that, in pursuing highly advanced and innovative design, it is ideal for the design division to not be excessively influenced by other divisions, and to have other divisions support the design division.

5.3 Design Division Involvement × Corporate-Wide Design Integration Organization

Third, our results showed that designs become more advanced and innovative when a corporate-wide design integration organization is put in place in conjunction with the consistent involvement of the design division from an early stage.

A corporate-wide design integration organization is differentiated as a functional department, and has authority to decide in matters of setting design strategy and allocation of resources. Thus, it can develop consistent designs by setting design strategy to complement corporate strategy and funneling design resources to product development projects that are higher priority from a corporate perspective.

When design divisions are incorporated into more self-contained organizations, the cost of coordination between design and other divisions goes down and work efficiency goes up. This is because highly integrated organizations can coordinate more efficiently, and knowledge transfer and sharing among organization members is more easily done (Lawrence & Lorsch, 1967). On the other hand, this kind of organization makes it difficult for the design division to spread its wings, which results in bland design (Morinaga, 2005). In addition, design groups within a divisional organization often compromise as they consider the intent of the entire organization, and there is a possibility of their participation in product development becoming more passive (Kanno, 2011). This is because divisional organizations act as independent corporations, with a strong tendency to prioritize

short-term profits or other goals (Chandler, 1962; Galbraith, 1973; Galbraith, 2002). Design development striving to be advanced and innovative is essentially in direct conflict with these divisional motives.

Because a corporate-wide design integration organization is functionally differentiated, it reduces designer passivity and compromises that are common of divisional organizations, and makes the early-stage involvement of the design division more effective. It should be noted, though, that placing a corporate design integration organization directly under purview of top management grants the corporate design integration organization authority equal to or greater than other divisions and gives legitimate authority over design strategy and resource allocation. This requires organizational backing of some sort to leverage this authority.

5.4 Design Division Involvement × Decision-Making

Fourth, our results show that designs become more advanced and innovative with the early-stage involvement of design divisions when the intentions of the design divisions are reflected in the ultimate decisions made regarding designs.

The results of our analysis suggest that reflecting the intentions of the design division on decision-making has a positive impact on advanced and innovative design. This shows that the consistent involvement of design divisions on upstream product development processes is meaningless without taking into account the intentions of design divisions in the decision-making process.

Morinaga (2008) notes that design in companies with many members involved in decision-making, and with diverse opinions contributing to ultimate designs through a consensus, tend to have bland designs. In obtaining a consensus, divisions with the most power or positioned higher in the corporate organization have their opinions reflected in design (Owen, 2000). Collegial decision-making by representatives from multiple divisions tends to give equal credit to the intentions of everyone involved in the decision-making process, thus damaging attempts at advanced and innovative design. In addition, even when the concerns of manufacturing and production divisions, such as efficiency and productivity, are reflected in designs, if these designs come at greater than expected costs or are difficult to manufacture, advanced and innovative design is likely to suffer.

Certain organizational structures, such as the positioning of design divisions high in the company, providing clear guidelines to prioritize design divisions, or top management decision-making that emphasizes design are all necessary to reflect design division intentions in decision-making.

The five results of our analysis given above are supported by the hypotheses of this study. Namely, the results show that merely involving design divisions in early stages of product development or management focused only on design divisions does not make it easier to create highly advanced and innovative designs. As companies position design strategy as a part of corporate management strategy, and create organizational structures and decision-making frameworks to implement the strategy, design strategy and the consistent involvement of design divisions in the product development process begins to take on meaning.

5.5 Design Division Involvement × Decision-Making

On the other hand, our results showed that even when design divisions had HR authority over designers, there was no impact on advanced and innovative design.

The results of our analysis conflicts with the assertions of existing research as well as this paper that tie design results to design division authority and centrality, and contradict the positive impact of creating a corporate-wide design integration organization.

On this point, it is possible to interpret this as the excessive decentralization of the corporate-wide design integration organization or design division. In the case of excessive decentralization, physical and psychological distance grows between design and other divisions, with information that is normally obtained by those close to customers, such as that acquired by operating divisions, becoming hard to come by for the design division. In addition, increasing distance from other divisions increases the risk of increased information processing and knowledge transfer costs.

Dumas (1995) noted that cross-functional groups must go through complex processes to exchange information in the pursuit of creating superior designs. Creating new knowledge at the group level requires mutual knowledge transfer and sharing among members (Nonaka & Takeuchi, 1995). Thus, implementing decentralization to such an excessive extent that the design division becomes physically and mentally distant from other divisions decreases information exchange between divisions and makes it difficult to create highly and innovative design.

In creating highly advanced and innovative design, the independence of corporate-wide design integration organizations and design divisions is a must. It is important for design divisions to have HR authority to make

this a reality, though schemes are necessary to promote information sharing and knowledge transfer between design and other divisions, such as by creating specialized staff to effectively coordinate between divisions or placing designers in locations physically close to operating divisions.

In this manner, we can infer that, as excessive decentralization moves forward there will be problems with barriers to information sharing, information fragmentation, and information processing costs, rather than with the transfer of HR authority to the design division itself. This poses a risk to advanced and innovative design.

6. Conclusion

The new findings uncovered by this study elucidate management requirements for the creation of highly advanced and innovative design, and show the impact of various organizational factors on design due to our analysis of these factors working in unison, rather than an analysis of them working separately.

Prior research (Walsh & Roy, 1985; Lorenz, 1990; Bailetti & Guild, 1991) emphasized the importance of designers, with their ability to integrate knowledge and information, as "gatekeepers," "connectors," and "integrators" in the product development process. This is because, in doing so, designers can maintain consistent product development and shore up designs that are both advanced and innovative.

In response to these studies, our research noted that simply having design divisions involved in the product development process from an early stage is insufficient, and that it is critical to analyze various organizational factors such as design strategy, inter-division coordination, organizational structures, decision-making frameworks, and where HR authority resides. In addition, our analysis showed how much each of these organizational factors impacted the early stage involvement of design divisions. This is the academic contribution of our research.

At the same time, merely managing for design divisions by itself is not enough to develop highly advanced and innovative designs in practice. Our analysis suggests the importance of corporate-wide design management that keeps in mind the various organizational factors discussed above.

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