Product Innovation Differences between New Ventures and Incumbent Firms

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ABSTRACT

While research has suggested new ventures create more innovations than incumbent firms, the differences of technological innovations, in terms of management knowledge and engineering focus, between new ventures and incumbent firms have been somewhat overlooked. For example, cost reduction, increased functionality and optimized performance are all deemed important irrespective of firm types. To identify innovation differences between new ventures and incumbent firms, we empirically compare a sample of 165 award-winning innovative products from either new ventures or incumbent firms using a framework of five major categories of innovation characteristics – functionality, architecture, user interactions, external interactions and cost. Our results show that, on average, innovative products from new ventures exhibited more characteristics of innovation than the ones developed by incumbent firms, implying new ventures may need to be more innovative than incumbent firms. The evidence shows no significant differences in the distributions of innovation characteristics across firm types. And yet most innovations occur in the categories of user interactions, external interactions and architecture, rather than the reduced cost and increased functionality categories that are the traditional focuses of many product development programs. Furthermore, our results indicate successful market adoption of new venture products may

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require a much higher rate of innovation characteristics than that of the new products from incumbent firms. These findings provide several nuanced managerial implications on the strategic scope and focus of innovation efforts for new ventures.

Keywords: Innovation, entrepreneurship, product development

1 INTRODUCTION

New ventures are playing an increasingly important role to the society by creating new technologies and innovations, and many suggested that new ventures are creating more innovations and innovative products than those established incumbent firms (Association of National Advertisers, 1984, Dennis, 2010, Lori, 2002, Teece, 1986). However, most studies of technology innovations either focus on the incumbent firms, or do not differentiate the innovations from new ventures and incumbent firms (Shane and Ulrich, 2004). In fact, the different economic and organizational characteristics of new ventures and incumbent firms may naturally result in different capabilities and strategies for new product development as well as different product characteristics, implying varied potential to penetrate the market. Understanding such differences may provide differentiated guidance to new ventures in their pursuit of innovative products. However, our knowledge of the innovation differences between new ventures and incumbent firms is still lacking.

The present study aims to fill this gap by exploring answers to three fundamental questions regarding the innovation differences between these two types of firms. 1) Should the level of innovation in new product designs be different between new ventures and incumbent firms? 2) Should the new product designs be innovative in different technical areas between new ventures and incumbent firms? 3) For new ventures versus incumbent firms, should higher

degrees of innovations sufficiently lead to higher potential of market adoption of the new product as well as growth of the company? Answering these questions will require methods to measure and compare firm characteristics with the technical details of their innovative new products.

In contrast, the past economic and management studies of technology innovations have mainly relied on patent count as the main measure of technology innovation (Fagerberg and Verspagen, 2009, Griliches, 1998), in addition to the limited studies investigating the matrix-based structure of product design, i.e. design structure matrix (Baldwin and Clark, 2000, Browning, 2001, Ulrich and Eppinger, 2000). To our best knowledge, new technologies themselves designed by new ventures and incumbent firms have not been differentiated in empirical studies of innovation management, which are primarily due to the lack of systemic methods or metrics to detect and compare the structures and properties of different innovative products.

To address this methodological challenge, we adopt a framework of characterizing innovative product designs established by Saunders et al. (2009, Saunders et al., 2011) from the engineering literature to measure and compare innovative levels of new products. Based on this framework, for a new product design to be considered as innovative it must present newness or improvements in five technical categories of product-level characteristics, including *Function*, *Architecture*, *External Interactions*, *User Interactions*, and *Cost*, which can be further decomposed into 13 subcategories (details will be introduced in section 4.1, but to clarify external interactions as those with other systems in the user environment). This framework allows one to detect the specific technical dimensions on which a new product is innovative or not, the overall level of innovativeness of the new product, and the distribution of innovations across different technical and economic dimensions. Therefore, this framework

holds the potential to advance the research on matching organizational characteristics to the innovation characteristics of their new product designs.

By adopting the Sanders et al. (2009, Saunders, Seepersad and Hölttä-Otto, 2011) framework to quantitatively assess a large sample of award-winning innovative products from either new ventures or incumbent firms, we find that new product designs from new ventures, on average, exhibit more innovation characteristics than those from the incumbent firms (section 4). While innovations generally occur in the *User Interactions*, *External Interactions* and *Architecture* categories, irrespective of firm types, the distributions of innovation characteristics across these main categories do not differ significantly between new ventures and incumbent firms. Furthermore, a higher level of innovations at the time of product launch is shown to be more correlated with the successful market adoption of the new products of new ventures than those of incumbent firms.

Our results begin to fill the gap of empirical knowledge regarding how various technical characteristics of innovative products are correlated with the types of organizations that developed them, particularly new ventures versus incumbent firms. Coupled with the existing knowledge that only a small fraction of new ventures and their products survive and thrive for a long term (Cooper, 2005), our new empirical findings provide implications to the risks involved with the development, marketing and diffusion of innovations, suggesting more systemic product-related strategies for new ventures to mitigate risks and improve the chances of long-term market success.

This paper is organized as follows. Sections 2 and 3 review the related literature and then develop the hypotheses for empirical testing. Section 4 explains the database and the key metrics for the empirical testing. Results are presented and discussed in section 5, which is followed by the conclusion section.

2 CHARACTERIZATION OF TECHNOLOGY INNOVATION

Due to its obvious importance, there have been increasing studies on innovations from both engineering and management perspectives (Fagerberg and Verspagen, 2009). On one hand, engineering research of innovations has focused on the physics of technology changes and the structure of products. For example, in order to understand the general patterns and trajectories of technology improvements through discrete technical innovations over time, many studies examined functional performance improvements (such as information processing rates, energy density and etc.) of various classes of technologies (Brock and Moore, 2006, Martino, 1971, Nordhaus, 2007). Key findings of such studies include that functional performance improvements of new technologies exhibit a general exponential pattern, and information processing technologies exhibit higher rates of performance improvements than energy processing technologies (Koh and Magee, 2008).

A different strand of engineering studies of innovations at the product-level focused on detecting the technical and cost dimensions where positive changes are made in a given innovative product. For example, recently, Saunders et al. (2009, Saunders, Seepersad and Hölttä-Otto, 2011) created a systemic set of technical and economic characteristics that describe the possible innovations in a product by investigating a large sample of award-winning innovative products. This framework allows one to detect the specific technical dimensions on which one product is innovative or not, and the overall level of innovativeness of a new product relative to the existing ones. However, the engineering studies of innovations do not consider the social and organizational factors that may indirectly affect the characteristics of the resulted technological innovations.

In economic studies, scholars focused on the socio-economical contexts and factors that may influence the success and failure of innovations (Freeman, 1974, Schmookler, 1962). The factors that have been widely examined include research and development spending (Arrow,

1962, Mowery and Rosenberg, 1998), industrial, market and institutional environment (Freeman, 1995, Lundvall, 1992, Nelson, 1993, Porter, 1990, Rosenberg, 1963), culture (Cohen and Levinthal, 1990, Teece and Pisano, 1994), and many others. Such studies normally treat technologies homogenously as commodities, relying on scalar measures such as patent counts, which do not look into the physical properties of technologies and products.

Strategy management studies of innovations have focused on firm-level capabilities for learning and experiments that allow the firms to continuously innovate (Cohen and Levinthal, 1990, Teece and Pisano, 1994). The structural dimensions of organizations, such as the decentralization of decision making, the links among divisions and vertical integration versus disintegration, are associated with different types of firm innovation capabilities (Fang et al., 2010, Kapoor, 2013, Sanchez and Mahoney, 1996). The studies of organizational design and capabilities are also linked to studies about the types and patterns of innovations. These studies explore the matching of organizational forms to the capabilities required to the pursuit of different types of innovation and respond to innovation discontinuity challenges introduced by competitors (Kapoor and Lee, 2013, Tushman and O'Reilly III, 2006). The well-studied patterns of innovations in the literature include architectural and modular innovations (Baldwin and Clark, 2000, Henderson and Clark, 1990) systemic and autonomous innovations (Chesbrough and Teece, 1996, Teece, 1996), radical and incremental innovations (Daft and Becker, 1978), and sustaining and disruptive innovations (Christensen, 1997). Although useful, this typology of innovations does not look inside the black box of technologies, ignoring the technical variables of innovations and biased toward social-economic factors extrinsic to technologies (Dennis, 2010, Song et al., 2010).

In addition, the new product development (NPD) literature, which cuts across engineering and management, has focused on methods to design and manage NPD processes (Krishnan and Ulrich, 2001, Otto and Wood, 2001, Ulrich and Eppinger, 2000), such as the "stage-gate

process" (Cooper, 2000), design structure matrix (Browning, 2001, Eppinger et al., 1994), Pugh method (Pugh, 1991); benchmarking the competition (Otto and Wood, 2001, Thevenot and Simpson, 2009), lead users (Von Hippel, 1986), and structured open innovation (Kain et al., 2011). However, the traditional NPD literature seldom differentiates different innovations in terms of the structure of technologies, and also seldom differentiates the organizational contexts for new product development, such as new ventures and established incumbents, whose varied natures blurrily imply different innovation requirements and approaches. The most common context of existing NPD research has been within large established companies.

In general, while the engineering research on innovation focuses on the structure and physics of products, the economic and management research on innovation has conversely focused on the social-economic factors extrinsic to technologies. The engineering and management-based understandings of innovation are highly relevant but only loosely connected in research.

3 INNOVATION DIFFERENCES BETWEEN NEW VENTURES AND INCUMBENT FIRMS: HYPOTHESIS DEVELOPMENT

There has been a rich literature regarding the differences in the organizational characteristics of new ventures and incumbent firms and some knowledge about the effects of such differences on the requirements, constraints and opportunities for technology innovations. Incumbent firms often have a large number of employees and assets that require formalized procedures and mechanistic organization structures to exercise managerial control and ensure efficiency, consistency, quality and reliability (Cohen and Levin, 1989, Dougherty, 2001, Rotemberg and Saloner, 1994), which makes them less nimble and innovative. As the firm grows and matures, bureaucracy develops and creates internal inertia to trials and changes in products (Gilder, 1988). In addition, an external source of inertia can be the large base of

existing customers and suppliers, whose existing needs must be continually satisfied (Christensen, 1997). Such rigidity and inertia limit creativity and innovation. Engineers may often find it difficult to make innovative changes and receive appropriate returns from their innovative efforts, so their risk-taking spirits and efforts may diminish. Some of the aspiring innovators will leave the incumbent firms to start their own ventures or join other new ventures (Klepper, 2007, Klepper and Sleeper, 2005, Lee et al., 2012).

In contrast, being new and small, new ventures are unencumbered by rigid rules and procedures, administrative hierarchy, bureaucratic rigidity, or inertia from the large base of employees, customers and suppliers. It is easier and simpler for new ventures to change products agilely and reward innovations properly. The perspectives of organizational rigidity, inertia and incentives seem to support the assertion that new ventures are more likely to have a higher level of innovativeness in their new product development than incumbent firms, which lead to our first hypothesis to empirically test in the present study.

H1) New products from new ventures have a higher level of innovativeness than new products from incumbent firms.

High level of product innovativeness may cause more challenges to market the new products and drive their adoption and diffusion, possibly resulting in the common observation that only a small fraction of new ventures and their products can survive and thrive for a long term (Song, Song and Parry, 2010). Following the viewpoint of disruptive innovations (Christensen, 1997), new venture products should be more innovative in the areas that bring down costs and make interfaces easy to use, whereas incumbent firms are more likely to pursue and succeed in innovations that improve main functionalities and technical performances. Therefore, it will also be interesting to see if *H1* holds for the different technical-economic categories of innovation.

Beyond this, we can pose hypotheses on the focus areas of innovation. Incumbent firms normally face lesser constraints in resources and capacities than new ventures. They already possess established assets from sales or stock markets to pursue capital-intensive R&D on sophisticated and systemic technologies (Damanpour, 1992). In addition, through their prior growth process, incumbents have already accumulated better equipment, human talents and experiences to deliver stronger R&D capabilities (Schumpeter, 1942). They are also more likely to integrate complementary activities, such as marketing or financial planning, with their external partnership resources to become a global research of information and technologies.

In contrast, most new ventures are unlikely to possess sufficient resources and capabilities to explore systemic and sophisticated technological improvements (Shane, 2009, Shane, 2008). Very often they do not have enough financial resources to attract more experienced engineer teams, purchase most advanced equipment, or conduct full-range complementary activities (Hurst and Lusardi, 2004). Past empirical research has confirmed the low efficiency and effectiveness in R&D among the majority of new ventures (Shane, 2009, Wong et al., 2005), which is primarily due to their constraints in resources, experiences, and capabilities. Thus, new ventures are less likely to pursue and succeed in technologically sophisticated innovations (Haltiwanger et al., 1999). Christenson (1997) and other scholars have advocated that new ventures, facing limited resources and capabilities, are more likely to succeed in the so-called "disruptive technologies" characterized by lowered cost, simplified design and increased ease to access and use, rather than improvements in system architectures or functionalities. Following these arguments, we propose the following hypothesis:

H2) The innovativeness of new products from new ventures and incumbent firms is focused on different categories of innovation.

Furthermore, many studies have suggested innovation is a leading factor in product and company success (Ali et al., 1995, Åstebro and Michela, 2005, Calantone et al., 2006, Chang et al., 2010, Kleinschmidt and Cooper, 1991, Lynn et al., 1996, Souder and Song, 1997). Yet, innovation alone is not a sufficient condition for success (Hlavacek et al., 2009), which also depends on brand prestige, managerial expertise, market environment, and many other factors (Cooper, 1979, Cooper and de Brentani, 1991, Marion and Meyer, 2011, Song and Parry, 1994). What are the innovation differences between the new products which are well-adopted by the market, of new ventures and incumbent firms?

New ventures are new and small by nature, normally do not have well-known brand names and prestige in the market, and have no mature marketing, sales, and distribution channels, which incumbents have already established in their successful past and can support the market adoption of a less innovative new product or a new product with only limited incremental innovation. Therefore, a higher degree of innovation may be more critical for the successful market adoption of new products of new ventures than those of incumbent firms. For this reasoning, we propose the following hypothesis:

H3) Successful market adoption of new products requires a higher level of product innovativeness for new ventures than incumbent firms.

While the successful market adoption of new products is important for all companies, it is even more pronounced for new ventures, where the initial growth of the company solely depends on the success of its first product (Song, Song and Parry, 2010). Therefore, a higher level of innovativeness in new products is critical for the successful growth of new ventures.

Taken together, the above hypotheses all focus on the innovation differences between the new products from new ventures and incumbent firms. Testing these hypotheses above would require a large sample of new products, measures of the level and scope of product

innovativeness, and also information on the type of firm, e.g. new venture versus incumbent firm. In next section, we will report our methods, measures, and data.

4 METHOD AND DATA

We test the aforementioned hypotheses using a sample of 165 mechanical and electrical consumer products, from either new ventures or incumbent firms, which have won an innovation or design award from either of the three public listings, including Time magazine's "Inventions of the Year", Popular Science magazine's "Best of What's New", and Industrial Designers Society of America's "International Design Excellence Awards (IDEA)", between 2003 and 2008. These products in our sample contrast to the vast new products in the market in that they were recognized by a panel of "innovators." Innovator recognition is the first stage of the well-accepted innovation diffusion process (Rogers, 1962) of five stages characterized by the adopters: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%). Whether the characteristics of such award-winning products differ between new ventures and incumbent firms were of particular interest.

In order to explore how innovation is different between the two types of organizations, we need (1) measures of product innovation characteristics, (2) information of the firm types as either a new venture or an incumbent firm when the product was launched, as well as (3) the information on the product adoption in the market place and the growth status of company in 2013.

4.1 Measure of Innovation Characteristics

First, to measure innovation characteristics of new products, we adopt Table 1 which Saunders et al. (2009) developed by analyzing and identifying the innovation characteristics presented in the products that won innovation awards from Time Magazine, Popular Science, and IDEA. The innovation characteristics were distinguished into five main categories as

follows: *Functionality*, *Architecture*, *External interactions*, *User interactions*, and *Cost*. Each of these categories has up to four more detailed characteristics as described in Table 1, with 13 sub-categories in total. These characteristics mostly cover the distinguishable advancements presented in a product that could be easily understood and accepted by the customers with limited technical background, as well as academic researchers in either engineering or management fields.

Table 1 Innovation characteristics analyzed in categories (Saunders, Seepersad and Hölttä-Otto, 2009).

Main Category	Detailed Subcategories and Descriptions
Function	*Additional Function* - Allows the user to solve a new problem or perform a new function addition to that of the comparison product.
Architecture	*Modified Size* - The physical dimensions during operation or storage have dramatically changed in expansion or compaction.
	Modified Physical Layout - The same elements of the product are still present, but the physical architecture has changed.
	Expanded Usage Physical Environment - The product can now be used in more usage environments with different resource availability or different physical characteristics.
External Interactions	*Modified Material Flow* - Accepts or creates different materials or uses materials in new ways.
	Modified Energy Flow - Utilizes new sources of energy or converts to a different form of energy than previously used.
	Modified Information Flow - Different types or amounts of information are being gathered, processed, or output/displayed.
	Interaction with Infrastructure - The product interacts with previously owned infrastructure.
User Interactions	*Modified Physical Demands* - The product is easier to use physically beyond subtle or incremental differences.
	Modified Cognitive Demands - The product is easier to use from a sensory standpoint beyond subtle or incremental differences.
	Modified Mental Demands - The product is easier to use mentally beyond subtle or incremental differences.
Cost	*Purchase Cost* - Purchase cost is significantly different.
	Maintenance Cost – Maintenance cost is significantly different.

This table is a useful tool to screen and identify the specific characteristics of innovation and total counts of innovation characteristics of a new product against other products commonly found in the market, especially the dominant designs whose architecture, specification and features set the technical standards and define a product category (Abernathy

and Utterback, 1978, Anderson and Tushman, 1990, Christensen et al., 1998, Utterback and Suarez, 1993). To better understand how one can use the innovation characteristics to assess the innovativeness of a new product, consider the following example.

Figure 1 Example of an innovation award-winning product: The Jawbone headset (photo by Robert Schlatter from Popular Science website).

The Jawbone headset in Figure 1 was original developed by Aliph, which is a company started by two undergraduates from Stanford University to develop noise-cancelling technology for the U.S. military. When the headset was first released to the market, the *Additional Function* of adaptive noise cancellation quickly differentiated this product from other competing headsets on the market. It could provide *Expanded User Environment* in a noisy background while the user could still make clear phone calls. The two-fold benefits, as a quality earplug for music listening and as a powerful headset for phone calls, interacted with the users' *Modified Sensory Demands*. It presented *Modified Energy Flow* because one of the sensors detects vibrations from human speech through the bones, which was different from other headsets with normal sensors to detect sound waves directly. During operation, it processes *Modified Information Flow* from the specially designed sensor placed against the user's cheek and another normal voice sensor to adaptively cancel the noise. Despite the special technology used, it is still compatible with a line of cellular phones at launch, which adds the characteristics of *Interactions with Infrastructure* to the product. In total, the Jawbone headset presented six characteristics of innovation.

After examining 197 award-winning new products, Saunders et al. (2011) found that the award-winning products exhibit on average three characteristics of innovation compared to the competition (e.g. dominant design) at that time. In addition to the count of characteristics, they also observed that, among the award-winning products, the top three most popular categories of innovation were *External Interactions*, *Architecture* and *User Interactions*. In comparison, innovations in the other two categories, *Cost* and *Function*, appeared rather rare among these award-winning new products.

Following this work, we use the count of innovation characteristics in a new product to indicate its level of innovativeness, and then follow the categories in Table 1 to investigate the distributions of innovation characteristics between new ventures and incumbent firms. We seek to investigate if and how innovation characteristics are different for different firm types.

4.2 Identification of Firm Type: New Ventures and Incumbent Firms

In the present study, we analyzed the products from the published database of Saunders et al. (2009, Saunders, Seepersad and Hölttä-Otto, 2011) as well as the histories of the firms that developed these products since the time when they won the product innovation awards. For each award-winning product, we performed online research to identify and confirm whether the firm that developed it is a new venture or incumbent firm, following a few pre-defined criteria.

While the literature suggested a number of ways to classify the types of firms (Acs and Armington, 2006, Barringer et al., 2005, Rosenthal and Strange, 2003), our main criteria are based on the resource-based view of firm growth (Penrose, 1959), competitiveness (Wernerfelt, 1984), and Howard Stevenson's view of entrepreneurship as "the pursuit of opportunity beyond the resources you currently control" (Jarillo and Stevenson, 1991, Stevenson and Gumpert, 1985, Stevenson, 1983). Following these views, a new venture must be 1) new and also 2) constrained in resources so that it has to venture, whereas an incumbent firm has existed in the

market for a long time and possesses more abundant resources. Considering the newness and lack of human and capital resources, a new venture often appears to be in business for a short time, small in size, limited in the variety of product offerings and in sales and distribution channels, and shows venturing and growing activities. Any company that is difficult to be classified according to the above criteria or unclear about their business status is excluded from our analysis.

We performed online research to explore information related to these aforementioned criteria to identify whether a new venture or incumbent firm developed each award-winning product. The resulting two classes of firms appear to be divided by the firm age of 8 years, defined at the time of winning the award from the founding years. This could be seen in plotting the distribution of firms in our data sample by firm age. We found that clearly classified new ventures are younger than or equal to 8 years old[†]. At the time of winning the innovation award, these firms generally exhibit limited human and capital resources, product line development, market establishment, and sales channels. On the other hand, the classified incumbent firms are older than 8 years. At the time of winning the innovation award, these firms have a well-known global brand name, such as Nike, Dell, 3M, etc., a major market share, and an established successful record in business for multiple decades.

4.3 Product Market Adoption and Company Growth Status

The innovation awards data spanned 5 years from 2003 to 2008 when this research was conducted. Five years after the last award year, the products and companies included in the analysis had gone through 5 to 10 years of evolution, market competition and selection. Thus, we are able to observe the degree of market success of these award-winning products in terms

[†]In one special case, we classified a 6-years-old company as incumbent firm, because the company was a spin-off founded with incumbent human and capital resources provided by the founders' previous employer, which was a large multinational firm.

of market adoption and company growth, given their innovation characteristics at the time of launch.

Our approach is to classify the product into *well-adopted* vs. *under-adopted* categories, and classify companies into *well-developed* vs. *under-developed* categories, based on public and online information. If a product is a market leader, followed with imitators, or becoming mature in 2013, is identified as *well-adopted*. On the opposite, a product that is still struggling for market entry or has been quickly extinct from the market is empirically identified as an *under-developed* product. While the incumbent firms have, by definition, established status before launching the product, the status of a new venture at the time of winning the innovation award needs to be evaluated. The new ventures with formal management structure, well-accumulated company resources, a clear technology roadmap and expanding product lines are empirically identified as *well-developed*. On the contrary, other new ventures that failed to show these key attributes, e.g. still struggling on the border of survival or existence after years of development etc., are identified as *under-developed*. The limited product line of new ventures, which often start with a single product, may determine a strong correlation between new venture's product adoption status and company growth status.

4.4 Data Sample

Our analysis data sample excluded some products and firms from the original 197 product data sample from Saunders et al (2009, Saunders, Seepersad and Hölttä-Otto, 2011), because we could not find sufficient information regarding their status to make a clear judgment of firm type[‡]. Of the 197 original products, 32 products are difficult to classify whether they were developed by incumbent firms or new ventures and are therefore excluded. As summarized in

[‡]For example, among the excluded products, one was actually marketed by a local distributor, four products were just concepts that have never been realized, and many have very limited information online for clear determinations.

Table 2, the resulting data sample of 165 products were designed by 111 unique firms, including 42 products from 41 new ventures and 123 products from 70 incumbent firms. Based on our search and analysis of the information about the status of products and companies, 127 of these products are empirically categorized as "*well-adopted*", while the rest 38 are "*under-adopted*" as of year 2013. For the 41 new ventures, 36 are categorized as "*well-developed*", and the rest 5 are "*under-developed*" as of year 2013.

Table 2 Sample database of products and the companies that developed these products.

Sample Products		New Venture Products (*N=42*)	Incumbent Firm Products (*N=123*)	Total
Product Adoption	Well-Adopted	38	89	127
	Under-Adopted	4	34	38
Sample Companies		New Ventures *(N=41)*	Incumbent Firms* *(N=70)*	Total
Company Growth	Well-Developed	36	68	104
	Under-Developed	5	2*	7

* No further analysis is conducted for incumbent firms, out of which 2 are bankrupted without further information.

5 RESULTS AND DISCUSSIONS

5.1 Level of Product Innovativeness of New Ventures vs. Incumbent Firms

Given our sample of award-winning products, we found that the products developed by new ventures presented 3.8 innovation characteristics per product, whereas the incumbent firm products have, on average, only 3.0 (Figure 2). A t-test shows the difference in the count of product innovations in new ventures versus incumbent firms is statistically significant with a p-value less than 0.01 assuming unequal variance. Further investigations to other non-technical factors, such as award sources (Time, Popular Science or IDEA) and product's launch year (2003 to 2008), found no significant effect on our results. These results suggest that, on average, products of new ventures present more innovation characteristics than that of incumbent firms.

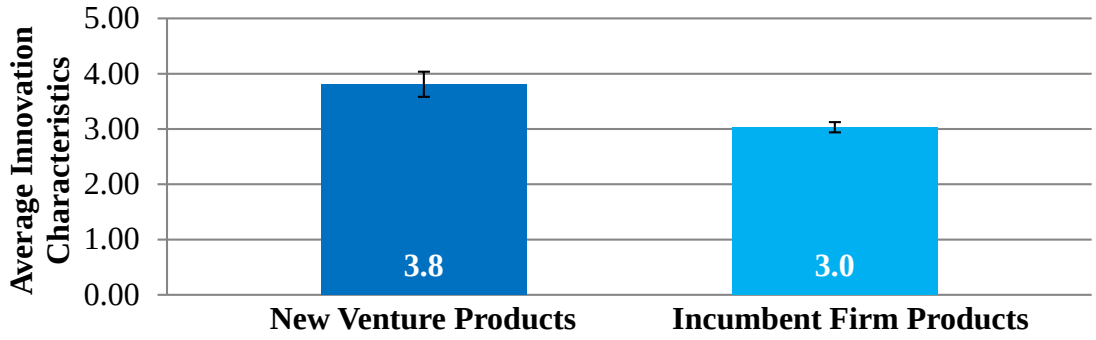

Figure 2 Average innovation characteristics of new venture and incumbent firm products.

Because the innovation characteristics were rated as positive integers only, the sample data could not be normally distributed. While such data is often nonetheless analyzed with the t-test and the conclusions practically remain valid, the confidence intervals on the means and therefore statistical validity are not assured. A test with less statistical power ought to be used, though the resulting p-values will likely be lower.

By nature, the Poisson distribution is a good candidate to describe the count of innovation characteristics in our sample, which generally represents the occurrence rate over time of an event in a finite observation space. Assuming a Poisson distribution, we performed the rate-test to consider the differences between the average rate of innovation characteristics in new venture and incumbent firm products. We found that the innovation characteristics are presented with significantly different average rates for new venture and incumbent firm products with an associated p-value of 0.02. While the average rate of innovation characteristics results were positively presented again, it may not be the case that the sample data is Poisson distributed, despite the inherent nature. A Chi-squared test for goodness of fit of the sample data with the Poisson distribution showed that the new ventures' product innovation data followed the Poisson distribution, but the incumbent firms' data may not.

Considering the violation of distribution assumptions in both the above t-test and rate-test, the non-parametric Mann-Whitney U-test is suggested to test for differences in medians. Statistically, the Mann-Whitney U-test is a non-parametric test with no assumption of any

specific distribution. In our sample, the medians of innovation characteristics in new venture and incumbent firm products are 4.0 and 3.0, respectively. Results showed that the total rank test score (U) is 4289 with an associated p-value less than 0.01. We thus conclude that new venture products and incumbent firm products present significantly different medians of innovation characteristics. The innovation characteristics are significantly different between new venture and incumbent firm products.

From the above analyses, one can generally conclude that new venture products are more innovative than the incumbent firm products, which supports hypothesis *H1*. Using the count of innovative characteristics per product as a measure of the level of innovativeness, we show that the innovative products from new ventures significantly present about one more innovation characteristic (median difference = 1.0; mean or rate difference = 0.8) than the innovative products from incumbent firms. New venture products present an average rate of 3.8 innovation characteristics to be considered innovative by the awarding agencies. On the other hand, incumbent firm products present only an average rate of 3.0 innovation characteristics to be considered innovative.

5.2 Innovation Differences across Characteristic Subcategories

In addition to the total count of innovation characteristics, we can study each main category of innovation characteristics to see if there is a difference on each individually. This is shown in Table 3. On each main category, we find that new venture products present a higher average rate of innovations than the incumbent firm products, which provides further support to hypothesis *H1*. Also, however, as was done earlier to compare the overall count of innovations, here the count of innovations in each category can be compared using a two-sample Poisson rate-test. From Table 3, the two-sample rate-test shows that there is no significant difference between the average rates of product innovations across firm types on every main category.

This result indicates that while new venture firm products have more innovation characteristics per product, this is true across all categories and not higher on any specific category.

Table 3 The two-sample Poisson rate-test for the main categories of innovation characteristics presented in 42 new venture products and 123 incumbent firm products.

Main Categories of Innovation Characteristics	Count of Innovations		Average Rate of Innovations		Two-sample Poisson Rate-test	
	New Venture Products	Incumbent Firm Products	New Venture Products	Incumbent Firm Products	Rate Difference	p-value
Function	17	46	0.40	0.37	0.03	0.785
Architecture	41	103	0.98	0.84	0.14	0.423
External Interactions	53	122	1.26	0.99	0.27	0.167
User Interactions	40	93	0.95	0.76	0.20	0.248
Cost	9	9	0.21	0.07	0.14	0.062

To further confirm this, we can complete a contingency table analysis, shown in Table 4, to determine if the percentages of product innovation characteristics change from new ventures to incumbent firms. The average rate of innovations columns in Table 3 is normalized to 100% for each of new venture and incumbent firm products, as shown in Table 4. If these percentages are the same for new venture and incumbent firm products, then there is no difference observed in the percentages of innovation characteristic types. The contingency table analysis produces a Chi-squared value of 2.213 with an associated p-value of 0.70. This indicates that there is no evidence for association between the percentages of main innovation characteristics presented in the product and the type of firms that developed the product. Independent of firm types, the innovations presented in these innovative products consisted of 33% *External Interaction*, 27% *Architecture* and 25% *User Interactions*. *Function* and *Cost* innovations are presented the least, at 12% and 3%, respectively.

Table 4 The contingency table of the main categories of innovation characteristics between new venture and incumbent firm products (p-value = 0.70).

Observed Percentages		Percent Rate of Innovation Characteristics	
		New Venture Products	Incumbent Firm Products
Innovation Characteristics Main Categories	Function	11%	12%
	Architecture	25%	28%
	External Interactions	33%	33%
	User Interactions	25%	25%
	Cost	6%	2%
Total		100%	100%

A possible issue in the above contingency table analysis is the low sample size on the cost category. Considering that the expected percentages of *Cost* in both new venture and incumbent firm products are less than 5%, we can redo the test by removing the *Cost* row and study the distributions of all other innovation characteristics between new ventures and incumbent firms. The Chi-squared value becomes 0.13 with an associated p-value of 0.99, which again supports the above result. Irrespectively, the dominant main categories of innovation in both new venture and incumbent products are presented in the categories of *Architecture*, *External Interactions* and *User Interactions*, with *Function* and *Cost* receiving a lower presence. This result is persistent and reinforces the previous result by Saunders et al. (2009) where the comparative analysis were made between award-winning and non-award-winning products.

Beyond the five major categories of innovation, we further examine the differences across all 13 subcategories of innovation characteristics as shown in Table 5. Again, we find that the differences in the rate of innovations per product are not significant in any particular category across firm types. The only exception is in the *Maintenance Cost*, where new venture products present a significantly higher rate of innovations with a p-value of 0.03. Unfortunately, however, the statistical power levels of the assertions in Table 5 are low ($\beta = 0.50$), and so the results remain inconclusive.

Table 5 The two-sample Poisson rate-test for the subcategories of innovation characteristic categories presented in 42 new venture products and 123 incumbent firm products, showing no differences between new ventures and incumbent firms.

Innovation Characteristics		Count of Innovations		Average Rate of Innovations		Two-sample Poisson Rate-test	
Main Categories	Subcategories	New Venture Products	Incumbent Firm Products	New Venture Products	Incumbent Firm Products	Rate Difference	p-value
Function	Additional Function	17	46	0.40	0.37	0.03	0.79
Architecture	Modified Size	13	27	0.31	0.22	0.09	0.35
	Modified Physical Layout	13	47	0.31	0.38	-0.07	0.48
	Expanded Usage Environment	15	29	0.36	0.24	0.12	0.23
External Interactions	Modified Material Flow	5	12	0.12	0.10	0.02	0.72
	Modified Energy Flow	22	50	0.52	0.41	0.12	0.35
	Modified Information Flow	15	39	0.36	0.32	0.04	0.70
	Interaction with Infrastructure	11	21	0.26	0.17	0.09	0.30
User Interactions	Modified Physical Demands	26	55	0.62	0.45	0.17	0.21
	Modified Sensory Demands	8	19	0.19	0.15	0.04	0.64
	Modified Cognitive Demands	6	19	0.14	0.15	-0.01	0.87
Cost	Purchase Cost	1	3	0.02	0.02	0.00	0.98
	Maintenance Cost	8	6	0.19	0.05	0.14	0.04

We can also perform the contingency table analysis for the percentages of subcategories, in a similar manner as was done with the percentages of the main categories. Again, we found no evidence exists for the association between the type of sub-categorical innovation characteristics presented in the product and the type of firms that developed the product. On the overall table percentages, the analysis produces a Chi-squared value of 2.96 with an associated p-value of 1.00. There is no significant difference on the percentages of innovation characteristics between new venture and incumbent firm products. The most important innovation characteristics are *Modified Physical Demands*, *Modified Energy Flows* and *Additional Functi*ons. The least important innovation characteristics are *Purchase Cost*,

Maintenance Cost and *Modified Material Flows*. These statements are true regardless of firm types.

From the above results about the percentages of main and sub-categories of innovation characteristics versus firm types, we have no evidence to support hypothesis *H2* (products from new ventures are focused on different categories of innovation). We find these combined results novel and interesting. Overall, successful innovative products from new ventures exhibit significantly more innovations per product, yet there is no particular pattern to those innovation characteristics that is more successful. New ventures simply need more.

5.3 Potential of Product Adoption and Company Growth by Innovation Characteristics

We further tracked the later status of these products and the firms that designed them over time. We assessed the success of each product after 5-10 years from the time of winning the award, which occurred between 2003 and 2008, and characterized each product as *well-adopted* or *under-adopted*, as defined earlier in Section 4.

Above all, a contingency table analysis for the numbers of *well-adopted* and *under-adopted* products across two firm types (see Table 6) shows that new venture innovative products with higher rates of innovation characteristics are more likely to be successfully adopted in the market place than those of the incumbent firms, with an associated p-value of 0.02. That is, product innovations from new ventures seem to be more related a successful adoption than product innovations of incumbent firms, according to our data sample. In the other words, the results indicate a successful market adoption of new venture innovative products may require a much higher rate of innovation characteristics than that of the new products of incumbent firms. Therefore, hypothesis H3 is supported.

Table 6 The potential of product adoption and company growth by innovation characteristics.

Innovation Characteristics (Number of Products)		Firm Type				Summary	
		New Ventures		Incumbent Firms			
		Average Rate of Innovations	N	Average Rate of Innovations	N	Average Rate of Innovations	N
Product	Well-adopted	3.8	38	3.0	89	3.2	127
	Under-adopted	3.5	4	3.1	34	3.2	38

A few additional observations are noteworthy. First of all, the last two columns of Table 6 show that the later *well-adopted* and *under-adopted* innovative products, regardless of the type of firm that developed them, present the same average rate of innovation characteristics (each at 3.2 per product) with a p-value of 0.86. The same rates of innovation characteristics exist for an innovative product, whether successful in the market or not. Said another way, high innovation is not indicator alone of market success.

However, difference observations perhaps can be made for different firm types. Table 6 exhibits that, for new ventures alone, *well-adopted* products present a higher average rate of innovation characteristics (3.8 per product) than the *under-adopted* ones (3.5 per product). A reverse result was found for the incumbent firms, where the *well-adopted* products present a *lower* average rate of innovation characteristics (3.0 per product) than those *under-adopted* ones (3.1 per product). If such difference holds true, it may partially result from the organizational characteristics and management approaches of incumbent firms, which are better suited for incremental innovative products. Unfortunately, the sample size is insufficient to conclude these observed differences.

Another observation from our data sample (see Table 7) is that new ventures with well-adopted innovative products are more likely to develop their firm well than those with under-adopted products. This result is significant with a p-value of 0.01 from a contingency table Chi-squared test. It indicates that the new venture will grow well if its initial product is successfully adopted, implying a successful new product in the market is critical to the company's

successful initial growth, for new ventures that often have limited product offerings. However, this observation might be a partial result of our sample bias that all the new venture products in our sample have already won at least one internationally renowned innovation award, which provides customers with more faith in the new ventures, despite of their newness and immature development, which in turn drives the sales. Taken together, the observations specific to new ventures in Tables 6 and 7 seem to suggest that higher rate of innovation characteristics may lead to company success for new ventures, whereas unfortunately our data sample is insufficient to provide statistical significance to this argument.

Table 7 Contingency table analysis of product adoption and company growth in new ventures.

Count of Products		New Venture		Total
		Well-developed	Under-developed	
New Venture Products	Well-adopted	35	3	38
	Under-adopted	2	2	4
Total		37	5	42

In brief, we find some preliminary evidence that successful market adoption of new venture products requires a higher level of innovation characteristics than incumbent firm products, and is also clearly correlated with successful initial firm growth of the new ventures, despite that the also observed correlations between innovation and product adaption for respective firm types remain inconclusive due to data sample limitations.

6 **CONCLUSIONS**

We set out to begin linking organizational and product innovation characteristics to develop better understanding of innovation between new venture startups and more mature and larger incumbent firms. By investigating a set of award-winning innovative products, we found statistical evidence that the products designed by new ventures have significantly more innovative characteristics than their counterparts from established firms. Also, in the most of

main and sub categories of innovation characteristics, new venture products present a higher average rate of innovations than incumbent firm products. This indicates that, in developing innovative products, new ventures may need to attack a wider set of characteristics, and pursue higher average rate of innovations in most of the characteristic category.

However, there were no significant differences in the percentages of each category of the innovation characteristics, i.e. the distributions of innovations across categories, between new ventures and incumbent firms. In other words, what aspect is innovative, or more innovative than others, seems to be the same across firm types. For both new ventures and incumbent firms, the *Cost* and *Function* categories received the lowest counts and do not significantly contribute to product innovations as much as other categories. While they are likely 'must-haves' or areas for incremental innovations, other categories, including *Architecture*, *External Interactions* and *User Interactions*, may contribute more to the 'delights.' This is an interesting additional insight from this study – identifying the types of innovation needed at the engineering level highlights how innovation is something beyond added function or reduced cost. Therefore, both new ventures and incumbent firms may find it more effective to innovate in categories including *Architecture*, *External Interactions* and *User Interactions*.

Our further results also indicate that a higher level of innovativeness may be needed for the later market success of new products developed by new ventures than those by incumbent firms, and driving the initial growth of the new ventures. Our analysis in this regard is preliminary due to the limitations in the indicators of product and company successes and related data availability. More investigation is expected to further detail how the innovation characteristics of new products at launch can help the company survive and grow in the long term.

A limitation to this study is that only a set of award-winning innovative products were analyzed, not all innovations in general, or innovations that failed; and thus the results only

indicate what can lead to product success, but not what could prevent failure. Another avenue for future work is to extend the work by Saunders et al. (2011) to include the degree of innovativeness rather than just a binary characterization of the count of innovation characteristics. In addition, factors other than organization type and innovation characteristics may also affect the later potential of product or company successes, such as technology maturity, human & capital resources, management style, entrepreneurial orientation, environmental conditions and policies. Future work should consider a broader set of factors that can also affect the successes of new ventures through product innovation (Day, 2007, Tang and Otto, 2009).

In general, our results contribute to the literature of innovation management by differentiating the characteristics of innovative new products and their potential in new ventures from incumbent firms. In particular, we hope the implications from our empirical findings may drive the entrepreneurs and innovators of new venture startups to more systematically understand and manage the consequences and risks involved with the development, marketing and diffusion of differentiated technology innovations, and improve the chances of long-term market success of their innovative products and ventures.

ACKNOWLEDGEMENT

This study is supported by the National Science Foundation CAREER award (No. 1150536) and the International Design Center at the Singapore University of Technology and Design. We also thank the participants at International Conference of Engineering Design and INFORMS Annual Meeting for their useful comments and suggestions. The authors alone are responsible for any errors and oversights.

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