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INNOVATION DIFFERENCES BETWEEN NEW VENTURE STARTUPS AND INCUMBENT FIRMS

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ABSTRACT
Innovation is critical to the long term success. Research suggests that new ventures create more innovations than larger established companies. Yet, engineering methods and technical focus areas for new product development are deemed no different from new ventures than established firms. Design to cost, increased functionality and optimized performance for example are all deemed important irrespectively. We empirically compare a sample of 92 award-winning innovative products from either new ventures or incumbent firms with respect to these five categories of product-level characteristics – cost, functionality, user interactions, external interactions and architecture. We show that, on average, award-winning products from the new ventures exhibited more characteristics of innovation than the ones developed by incumbents. This indicates that new ventures need to be more innovative than incumbents. Also interestingly, the distribution of innovation characteristics exhibited by innovative products remained unchanged between new ventures and incumbent firms; most innovations occur in the user interaction, external interaction and architecture categories, irrespective of firm type.

Keywords: innovation, entrepreneurship, new product development

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1 INTRODUCTION

In today's knowledge economy, companies race to proactively introduce innovations in order to gain competitive edge in the marketplace, and respond to the innovations introduced by competitors and complementors (ASME, 2004). *Technology* innovation, specifically, has been identified as the most fundamental driver of economic growth (Porter, 1990) and the accumulative force to sustain economic growth (Luo, et al. 2012). Robert Solow's Nobel Prize-wining research (1957) estimated that more than 80% of long-term GDP growth is driven by technical innovation.

Due to its obvious importance, there has been increasing studies on innovation (Fagerberga and Verspagenc, 2009). While engineering research on innovation has focused on the structure and physics of products (Saunders et al. 2011; Koh and Magee, 2006), they seldom consider the social, economic, and organizational issues involved which can affect the innovation process. In parallel, management research on innovation has largely treated technologies as black boxes while focusing on the social-economic factors extrinsic to them (Dennis, 2012; Song et al. 2010). The present study attempts to start bridging this gap by considering the characteristics of innovative products and the characteristics of the organizations that develop them. Specifically, we seek to identify the differences in the technical characteristics of innovative products that are developed by two distinct types of organizations: new ventures and established companies, i.e. incumbents.

Research has suggested that new ventures create more innovations and more innovative products than larger established companies (Dennis, 2012; Song et al. 2010; National advertisers, 1984; Lori, 2002). While significant research exists to support the increasingly important role of new ventures to society in creating new innovations, it is not clear if and how the technical innovation process, or product development in general, should be same or different in new ventures in contrast to incumbents. Petetin et al. (2011) suggest a process for small and medium sized firms, one that differs from innovation processes for larger firms, but clear validation or relation to startups is still missing. Meanwhile, unlike incumbents, only a small fraction of new ventures and their products survive and thrive (Cooper, 2005). New ventures and incumbents have very different economic and organizational characteristics by nature, which may potentially affect the approaches they use develop new products, the characteristics of the new products, and the products' potential to be commercialized and/or diffuse in different markets. However, understanding of how innovations from new ventures and incumbents differ is lacking.

Saunders et al. (2009, 2011) established that to be considered innovative, improvements must be exhibited in more than one of five technical engineering categories of product-level characteristics, including functionality, architecture, external interactions, user interactions, and cost. In this study, we empirically compare a sample of 92 award-winning innovative products from either new ventures or incumbent firms with respect to these five categories of product-level characteristics. Our results show that, on average, award-winning products from the new ventures exhibited more characteristic categories of innovation than the ones developed by the established companies – new venture products show not just one or two innovative features but many. New ventures also exhibited higher rates of innovation than incumbents, generating new products with more innovations in each of the five categories. These new findings provide important implications to the risks involved in the market attack planning and technology diffusion processes, suggesting strategies for new ventures to suppress risks and improve the chance of market success of their products.

2 CHARACTERISTICS OF NEW PRODUCTS AND FIRM TYPES: NEW VENTURE VERSUS INCUMBENTS

Our research is built on two streams of literature: characteristics of product innovation, and characteristics of new ventures versus incumbents. We will review both of them in the following.

The studies of innovation have classified it as a phenomenon in a number of ways, such as product and process innovation (Utterback and Abernathy, 1975), architectural and modular innovation (Henderson and Clark, 1990; Baldwin and Clark, 2000) systemic and autonomous innovation (Teece, 1996; Chesbrough and Teece, 1996), radical and incremental innovation (Daft and Becker, 1978), and sustaining and disruptive innovation (Christensen, 1997). These classifications have allowed for further exploration of matching organizational forms and capability sets with different types of innovation, and the responses to the discontinuity challenges from different types of innovations

introduced by competitors (Tushman and O'Reilly, 1996; Kapoor and Lee, 2013). Although useful, such typology of innovation does not look inside the black box of technologies, ignoring the technical and engineering methodology contributors to innovation.

From the management perspective, incumbents and new ventures differ on several dimensions, which may affect their innovation processes and outcome. First, incumbents often have a large number of employees and large assets that require formalized procedures and rules, as well as mechanistic organization structures, to exercise managerial control and ensure efficiency, consistency, quality and reliability (Cohen and Elvin, 1989; Rotembert and Saloner, 1994; Dougherty, 2001), making them less nimble and innovative. Unfortunately, bureaucratic inertia may develop as the firm grows and matures (Gilder, 1988). A large base of existing customers or suppliers can be an additional source of inertia (Christensen, 1997). Such rigidity and inertia limit creativity. Engineers may also find it difficult to appropriate returns from their innovative efforts, so their risk-taking spirits and efforts may diminish. Some of them aspiring innovation will leave incumbents to join new ventures or start up their own. In contrast, being new and small, new ventures are not unencumbered by rigid rules and procedures, administrative hierarchy, bureaucratic inertia, or the large number of employees, customers and suppliers. It is also simpler for new ventures to reward innovation. All these factors seem to support the assertion that new ventures are more likely to introduce radical innovations than incumbents.

However, new ventures normally face stronger resource and capacity constraints than incumbents. Incumbents have larger sales volume to generate returns or abundant capitals from public/stock markets, which allow them to pursue substantial and radically-innovative technologies (Damanpoor, 1992). Through the growth process, incumbents have accumulated better R&D equipment, personnel and knowledge, indicating higher R&D efficiency and effectiveness (Schumpeter, 1942). They are also more likely to well conduct complementary activities, such as marketing or financial planning, which enable them to have greater global research of information and other resources. In contrast, most new ventures are unlikely to have the resources and capabilities required to explore substantial and radically-innovative ideas (Shane, 2008; 2009). They do not have financial resources to attract high quality engineers, purchase advanced equipment, or conduct full-range marketing research and complementary activities (Hurst and Lusardi, 2004). As a result, new ventures may face high uncertainty. They also do not have sufficient resources to maintain a large portfolio of new products to deal with the uncertainty (Lofqvist, 2011; Eben et al., 2011). Past empirical research has increasingly shown that most new ventures are rather inefficient, with a few outliers that contribute to the majority of innovation and breakthroughs (Wong et al., 2005; Shane, 2009). Therefore, from the perspective of resource and capability, new ventures are less likely to achieve radically-innovative products than incumbents (Haltiwanger et al. 1999).

On the engineering side, many methods have been developed and widely adopted for new product development. Most such widely-used methods do not address innovation directly. For example, the design-for-X methodologies aim to reduce assembly, end-of-life, etc. costs. These and other traditional methods fail to provide guidance for innovation. Benchmarking the competition (Otto and Wood, 2001, Thevenot and Simpson, 2009) is an important part of product development, but it tends to be limited to incremental innovation. Innovation typically responds to not yet articulated, so called latent needs (Von Hippel, 1986). Some methods, such as lead users (Von Hippel, 1986) and structured open innovation (Kain et al. 2011) are more targeted toward innovation, but they do not guarantee product success. There are many metrics developed and used for the concept selection phase to help select the best concept (Pugh, 1996, Ulrich and Eppinger, 2011; Goldense, 2000). These metrics include meeting of customer needs, technical feasibility, and expected benefits to the firm such as Return on Investment (ROI). These types of metrics are commonly used in industry (Takala and Holtta, 2001). However, these standard metrics can lead to non-innovative mediocre concepts, because innovation is not used as a criterion (Cooper, 2005).

In the meantime, outside of considerations of innovation, there are a separate streams of research focusing on the new product development (NPD) process and organization (Otto and Wood, 2000; Eppinger and Ulrich, 2001; Krishnan and Ulrich, 2001). Such studies have suggested various organization approaches to manage and revise new product development, such as a "stage-gate process" (Cooper, 2000). Within this, the literature does indicate that innovation and competitive advantage are leading factors in product success (Ali et al. 1995; Lynn et al. 1996; Souder and Song, 1997; Chang et al. 2010; Calantone et al. 2006). We seek here not to use innovation as an input factor to success, but rather treat it as an output to be described with further independent factors. For

example, the traditional NPD literature seldom distinguishes the types of organizations, such as new ventures and established incumbents, whose varied natures blurrily imply different innovation requirements and approaches. Further, the most common context of existing NPD research has been within large established companies. Our understanding is therefore relatively limited in the development process explanation of how innovations from new ventures will emerge and succeed in a different way.

Recently, Saunders et al. (2009, 2011) created a systematic set of characteristics that describe possible changes in a general product, in five categories including functionality, architecture, external interactions, user interactions, and cost. This framework allows one to detect the specific technical dimensions on which one product is innovative or not, and the overall degree of innovativeness of a new product relative to an existing one. Therefore, this framework holds potential to advance the research on matching organizational forms and capabilities sets with the types of innovation by distinguishing new products at greater technical details, for instance, the degree of innovativeness and the dimensions of innovativeness.

3 METHOD AND DATA

In order to identify how innovation is different between the two types of organizations, new ventures and incumbents, we apply the innovation characteristics developed by Saunders et al. (2009). A set of characteristics was developed by analyzing products from published lists of best products in Time Magazine and Popular Science as well as IDEA award winners. The characteristics are distinguished into five categories as follows: Functionality, Architecture, External interactions, User interactions, and Cost. Each of the categories has up to four more detailed characteristics as described in Table 1.

In the study, innovative award-winning products were analyzed against all other products commonly found in the market. Products were selected from three published lists of innovative products: 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 in the years from 2006 to 2008, rather than personal choices by the authors. Winning such innovation awards indicates their similar degree of success as being recognized by the "innovators" group of adopters. This is the first stage of the well-accepted innovation diffusion process (Rogers, 1962) of five subsequent stages characterized by the adopters: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%). Although tracking and measuring the successes of these products will be difficult, they have contrasted to the vast new products in the market that never get recognized and fail without being known by the public.

To better understand the characteristics, consider the following example. Plug and Play Ultrasound Probe (Figure 1), sold as NuWave by Laborie, is a product of a new venture Direct Medical Systems started in, 2005, one year before the launch of the successful Plug and Play. The Plug and Play is innovative compared to other ultra sound imaging systems available (in 2006 when launched) in that it is powered by a laptop. This means significant reduction is energy use (category Modified Energy Flow); it interacts with existing equipment (the laptop) via a standard USB connection and thus hits category Interaction with Infrastructure. Being powered via an USB also enables use of the system in rural locations where no power is available (category Expanded Usage Environment). It is also significantly smaller (Modified Size) and has a Modified Physical Layout when compared to the competing systems. In total, the Plug and Play hits five characteristics of innovation. Saunders et al. (2009) found that these award-winning products exhibit, on average, three characteristics of innovation compared to zero by the competition at that time. Even after being in the market, the innovative award winning products exhibited over two characteristics compared to one characteristic by the competition (Saunders et al. 2011).

Figure 1. Plug and Play Ultrasound Probe, example of an award winning innovative product

Table 1. Characteristics of innovation (Saunders et al. 2009)

Main category	Detailed category and description	% of products w/ character.	% of products in the categ.
Function	*Additional Function*- Allows the user to solve a new problem or perform a new function addition to that of the comparison product.	38.1	38.1
Archi-tecture	*Modified Size*- The physical dimensions during operation or storage have dramatically changed in expansion or compaction.	23.4	60.9
	Modified Physical Layout- The same elements of the product are still present, but the physical architecture has changed.	36	
	Expanded Usage Physical Environment- The product can now be used in more usage environments with different resource availability or different physical characteristics.	26.9	
External Interactions	*Modified Material Flow*- Accepts or creates different materials or uses materials in new ways.	10.2	80.2
	Modified Energy Flow- Utilizes new sources of energy or converts to a different form of energy than previously used.	41.6	
	Modified Information Flow- Different types or amounts of information are being gathered, processed, or output/displayed.	34.5	
	Interaction with Infrastructure- The product interacts with previously owned infrastructure.	20.8	
User Interactions	*Modified Physical Demands*- The product is easier to use physically beyond subtle or incremental differences.	48.7	68.5
	Modified Sensory Demands- The product is easier to use from a sensory stand point beyond subtle or incremental differences.	14.2	
	Modified Mental Demands- The product is easier to use mentally beyond subtle or incremental differences.	15.7	
	Purchase Cost- Purchase cost is **significantly** different.	2.5	9.1
Cost	*Operating Cost* – Operating and/or maintenance costs are **significantly** different.	7.1	

Saunders et al. (2009, 2011) however did not investigate if these characteristics are different for new ventures and established companies. In this study, we randomly picked products from their database to investigate the history and characteristics of the firms which developed the products. For each product, we performed online research to identify and confirm if it is designed by a new venture or incumbent firm. A firm is defined as an incumbent if it has clearly established a globally-well-known brand name, such as Samsung, Ford, Black & Decker, and/or a multi-decade successful record in business. In contrast, a firm is defined as a new venture if it was recently founded (within 0-10 years before the launch of the product), shows a growth record (from online documentation), and has no evidence of clear establishment in the market. Products and companies for which we could not find information or were unsure about its firm type were not included in our sample. The resulting sample included 92 products, 32 of which are from new ventures while the rest are from incumbents.

3 RESULTS

We find that new venture innovative products have, on average, 3.53 different characteristics of innovation whereas the incumbent innovative products have, on average, only 2.78 (Figure 2). Recall the number of innovation characteristics per product for all the firms, as reported by Saunders et al. (2011), was 3.0. We compared the difference in the mean number of characteristics of new ventures versus incumbents using the t-test and find that the difference is statistically significant with a p-value of 0.0056. With this, one can conclude that innovative products of new ventures attack more innovation characteristics than innovative products of incumbents.

We also investigated if other non-technical factors were significant, such as the source of the award (one of the three lists) or the product's launch year. These factors did not have a significant effect.

While a positive result, a problem is that the data is by nature bounded at the lower end by zero innovative characteristics and therefore cannot be normally distributed. Using the Anderson-Darling test for normality, both the new venture and incumbent data were statistically significantly different form normal data, as expected. Innovation characteristics receive only positive integer values. This

type of data is similar to defect detection in quality control, for example, where the data is rate (number) of defects per product. While such data is often nonetheless analyzed with the t-test and the conclusions practically remain valid, the confidence intervals are on the means and therefore strict statistical validity is not assured. A test with less statistical power ought to be used, though the resulting p-values will likely be lower.

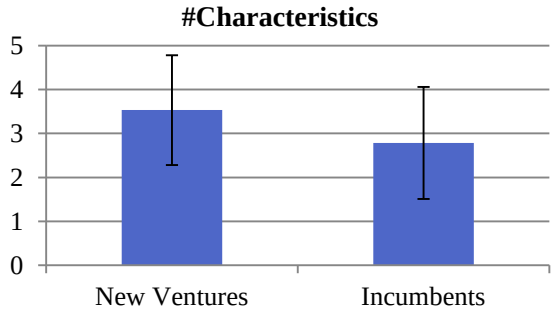

Figure 2. Number of innovation characteristics hit by new ventures and incumbents

From first principles, counts of events per unit are naturally represented with the Poisson distribution, i.e. here we count the rate of innovation characteristics per product. The Poisson distribution rate-test establishes whether two Poisson distributed data sets have a different average defect rate. The rate-test was calculated to determine if the average rate of innovation characteristics occurrence is the same in the lists of products from new ventures and incumbents. The results are shown below in Table 2.

Table 2. Rate of occurrence analysis results

Sample	Total occurrences	N	Rate of occurrence
(1)New Venture Products	113	32	3.531
(2) Incumbent Products	167	60	2.783
Difference = rate(1) - rate(2) Estimate for difference: 0.748 95% CI for difference: (-0.028, 1.524) Test for difference = 0 (vs. not = 0): Z = 1.89 P-Value = 0.059 Exact test: P-Value = 0.060			

As can be seen in Table 2, the data demonstrates a p-value of 0.06 significance that new ventures have more (3.53) innovations per product than established incumbent companies (2.78 innovations per product). We are 94% confident that new ventures have more innovation characteristics than the incumbent companies (that 3.53 > 2.78).

While again indicative and positive, the data sets themselves were not necessarily Poisson distributed, despite the inherent nature of the source of the data. Applying the Chi-squared goodness of fit test to the data, the new venture data was statistically no different from Poisson-distributed data, but the incumbent company data was statistically significantly different from a Poisson distribution.

Statistically, this leaves distribution-free methods to compare the data. In replacement of the t-test or rate-test, the Mann-Whitney test can be computed; though again with less statistical power (it requires more data to attain a significant p-value than a t-test). The Mann-Whitney test determines if two samples are drawn from the same population, and considers both location and dispersion of the data. The Mann-Whitney test was executed to determine if the distribution of innovation characteristic counts is the same in the lists of products from new ventures and incumbents. The results are shown below in Table 3.

As can be seen in Table 3, the data demonstrates a p-value of 0.01 significance that new ventures are distributed differently (here larger) than established incumbent companies. Nothing can be said about parameters of the distributions such as the mean, but nonetheless the samples are representative of statistically significantly different populations.

Table 3. Mann-Whitney distribution free analysis results

Sample	N
(1)New Venture Products	32
(2) Incumbent Products	60
U-Value	1231
P-value	0.0129

From these three analyses, the conclusion to be drawn is new venture products hit more innovative characteristic categories than established incumbent company products. The best estimate for the actual difference in the average rate statistic is that new venture products have slightly more than one (0.748) additional innovation characteristic than products from incumbents, and must exhibit 3 to 4 innovative characteristics (3.53) to be sufficiently innovative and successfully enter the market. Incumbent firms need only 2 to 3 characteristics (2.78) on a new product and it will be considered innovative, and given their entrenched position that is sufficient for the product to be successfully launched in the market. The confidence interval on this difference in average rate remains indeterminate however, since no parametric distribution could be significantly matched to the sample datasets.

In addition to the number of characteristics, Saunders et al. (2011) had observed that the top three most important areas of innovation were External Interactions, Architecture and User Interactions. The other two categories, Cost and added Functionality were significantly less important for success. The question we pose here is whether that remains true for both new ventures and established incumbent companies.

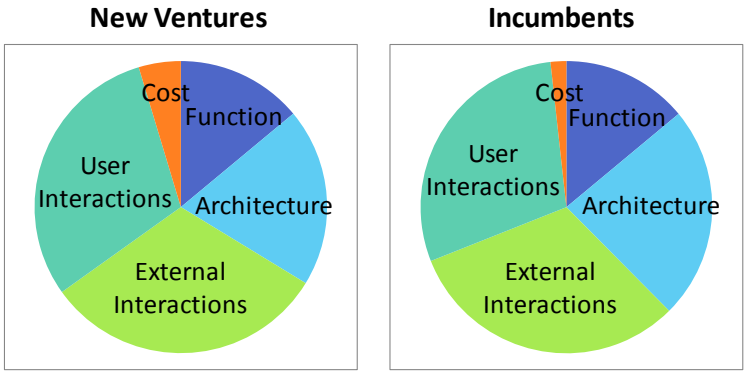

Figure 3. Types of innovation characteristics by new ventures and incumbents.

As shown in Figure 3, we find that the conclusions hold true for both new ventures and large firms. Overall the new ventures had more in each five categories of innovation characteristics, but the difference was not statistically significant. User Interactions, External interactions and Architecture remain the categories of innovation that occur most often, independent of type of firm. Innovations in cost and added functionality remain less common in products deemed highly innovative.

4 DISCUSSION

We set out to start linking organizational and product innovation characteristics to get better understanding of innovation in new venture startup and more mature and larger incumbents. We investigated a set of award-winning innovative products to answer two questions: "Should the level of innovation be different in new ventures than in larger more mature firms?" and "Should a new venture be innovative in different areas than a larger more mature company?" We found statistically significant evidence that products that were created by new ventures had significantly more innovation characteristics than their counterparts from established firms. This indicates that, in developing innovative products new ventures may need to attack a wider set of characteristics.

This result is indicative of the new venture at launch, further research is needed to investigate how innovative products at launch help the company survive and grow in the longer term. Further, a limitation to this study is that only a set of award winning innovations was 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 degree of innovativeness rather than just a binary characterization of the innovation characteristics hit.

The second part of the analysis was to see if there is a difference in the types of innovation, or more specifically the types of innovation characteristics, between the new ventures and incumbents. We find that while the new ventures had, on average, more characteristics in each category when compared to the incumbents, there was no statistically significant difference in the percentages of each category. In other words, what is innovative seems to be the same across the company types, at least in the area of consumer products. We suspect that the cost and functionality categories, the two areas that received the lowest counts, are likely must-haves or, at best, baseline needs in the Kano sense (Kano 1984), while the other categories help contribute 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: those two categories do not significantly contribute to product innovation as other categories. We therefore assert that added function and reduced cost are properties of incremental innovation and therefore both new ventures and mature companies both need to look at innovation through the wider scope of the other innovation categories.

Finally, it would be interesting to investigate the predictive power of the innovation characteristics. Could they aid the engineering process in identifying areas of product improvement? For example, consider a new venture developing a battery technology for mobile devices as a software based application that can extend battery life. Conceivably, they could improve their chance of success, or at least product recognition in terms of awards and media coverage, by using the above innovation characteristics framework. If their technology is currently hitting two characteristics such as 'Modified Physical Layout' and 'Modified Energy Flow,' then the team could decide to change the design to increase the number of characteristics, rather than simply a larger difference on these two. Being a new venture, they would like to hit over 3.5 characteristics. The team could, for example decide to change to target electric vehicles instead of mobile devices. This way they would also hit the 'Expanded Usage Environment' category since the technology would significantly extend the range of the vehicles. The team could further include features that helped save in battery maintenance, by including diagnostic features or they could evolve the technology to lengthen the maintenance interval of batteries. These innovation characteristics, however, are only a part of the equation for business success. It remains to be seen how well these characteristics can be used to predict success, but as we showed in this paper new ventures need more innovation characteristics when compared to more mature companies.

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