# PRODUCT SOCIAL CAPITAL: MEASURING THE IMPACT OF DESIGN ON CORPORATE PERFORMANCE

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## ABSTRACT

It is difficult to measure the value of effective Product Design in the success of innovative products because design teams are typically treated as cost centers rather than as sources of revenue generation. Other business activities such as sales lend themselves to simpler measure such as Gross Revenues, whereas design efforts get lumped into the cost side of gross margin calculations. Applying this mindset to design metrics marginalizes Product Design efforts as cost centers, making them ripe for cost reduction, rather than measuring the impact Product Design activities have on the efforts of an enterprise to create value. Methods such as Design for Manufacturability and Design for Assembly focus primarily on reducing downstream product costs. Much of the investment in Computer Aided Design (CAD) tools and Product Data management (PDM) systems has been driven by promised reductions in the length and cost of the design cycle. Cost reductions of this sort lend themselves to facile instrumentation and are easier to account for on the corporate balance sheet. No widely accepted design metric accounts for the impact design efforts have on Corporate Performance. The Product Capital Model is a recently developed framework (Feland 2005) that provides metrics for assessing the impact of design on Corporate Performance. Product Social Capital, one class of metrics from the framework, may have potential as a leading indicator of future product sales. This could imply a causal relationship between good design and good business. This hypothesis is tested against cases from the consumer electronics industry and the automotive industry. Implications of the results are reviewed for their impact on design research and design practice.

*Keywords: Product Innovation, Design Metrics, Social Capital, Corporate Performance*

## 1 INTRODUCTION

Product Social Capital is one of three domains of an assessment framework that has demonstrated the impact of design on Corporate Performance [Feland, 2005]. The Product Capital Model was derived from the precept of Comprehensive Design Engineering [Feland, Leifer, Cockayne, 2004]. Comprehensive Design Engineering holds that effective design considers Business, Human, and Technical factors when attempting innovation. The following list connects Comprehensive Design Engineering to the Product Capital Model.

- Business Factors (*viability*) → Product Financial Capital
- Technical Factors (*feasibility*) → Product Intellectual Capital
- Human Factors (*desirability*) → Product Social Capital

The Product Capital Model successfully connects design performance to Corporate Performance. (Feland 2005) The design performance of Personal Digital Assistant (PDA) manufacturers Palm and Handspring was measured using metrics of Product Financial Capital, Product Intellectual Capital, and Product Social Capital. Product Financial Capital metrics consider financial measures pertinent to the design and deployment of innovative products. Product Intellectual Capital measures the knowledge work generated by design efforts. Product Social Capital metrics assess the strength of the relationship between the product and the end user. This data was then correlated with three measures of Corporate

Performance, Market Capitalization, Gross Revenues, and Return on Assets. Statistically significant correlations were found for all three Corporate Performance measures, supporting the adage that good design is good business. The Product Capital Model outperforms traditional financial measures when modeling the Market Capitalization and Gross Revenues of Palm and Handspring.

## 2   THEORETICAL FOUNDATION OF PRODUCT SOCIAL CAPITAL

Notions of Social Capital have been growing more prevalent in the academic and business literature since Jacobs (1963) first introduced the concept in his study of what distinguished strong city neighborhoods from those that fall into decay. Social Capital has been used to study and explain the evolution of Silicon Valley (Saxenian, 1994) and to explain how certain cities limit innovation and entrepreneurship (Florida, 2002). Traditionally applied to people and organizations, Social Capital has never been applied to products. Here we apply this construct to products as well as develop a few metrics for what is known as Product Social Capital.

Robert Putnam (1993) defines social capital as the

> *"complex of local institutions and relationships of **trust** among economic actors that evolve from unique, historically- conditioned local cultures."*

Charles Sabel (1993) defines trust as "the mutual confidence that no party involved in an exchange transaction in the market will exploit the others' vulnerability." Sabel's "trust" is analogous to Putnam's "social capital." Mark Granovetter (1985) insists that trust is

> *"embedded in networks of interpersonal relations which avoids the extremes of both under-socialized [market-oriented, rational choice] and over-socialized [legal institutional] views of human action."*

Cohen and Fields (2000) challenge this notion as not being relevant to Silicon Valley. Their argument is that given the diverse and transient nature of Silicon Valley, it is a lack of Putnam's social capital that enables the valley's drive. Robert Florida reports similar findings in his book, *The Rise of the Creative Class* (2002). Florida finds that locales with low social capital and high bohemian and gay populations facilitate open ideas. His research efforts find that locales that have high levels of Putnam's notion of social capital actually inhibit innovation. Granovetter also sees increased trust within a network as limiting extremes of behavior, such as starting companies. These definitions of social capital focus on the interactions between individuals and organizations. In the aggregate, increased trust and social capital within the network can limit efforts to innovate.

### 2.1   Product as an equal actor in a social network

Imagine extending the boundaries of Granovetter's network to include products. This is the exact notion behind Actor Network Theory (ANT) (Latour 1986, Callon 1986). Actor Network Theory describes "a society of humans and non-humans as equal actors tied together into networks built and maintained in order to achieve a particular goal, for example the development of a product" (amsterdam.nettime.org). By blending the construct of Actor Network Theory with the previously outlined views of Social Capital, we can begin to examine the trust between the product and end user. This special case of Social Capital is what we define as Product Social Capital.

When people purchase products, they enter into a contract similar to Sabel's definition of trust. Noted Harvard Business School professor Theodore Levitt spoke of hiring a product to do a job. His classic example is that people do not purchase a drill bit to buy the bit, but because they want a hole. The consumer trusts the product to perform a specific job. The consumer believes that the product will not exploit their vulnerabilities. Increasingly, we see the anthropomorphizing of products by their owners (Reeves & Nass, 1996). One Palm customer commented in a review, "If we could marry electronic devices, this PDA and I would be engaged."

Design teams have a significant influence over the trusted relationship between the product and end user. Regardless of what the marketing hype suggests the product provides, it is the design team that ensures the product actually delivers what was promised. When that trust is maintained, there is joy in the relationship and the user continues to perceive benefits in this relationship. Considering this context, I offer the following definition of product social capital for the purpose of this research:

> *Product Social Capital is the persistent trust or perception of benefit by the end user of a product.*

## 2.2    Product Social Capital Differs from Customer Satisfaction Measures

There have been other research efforts that explore the relationship between customer satisfaction and Corporate Performance. Ittner and Larcker's (1998) examine the impact of customer satisfaction using examples from a telecommunications service provider. They perform a business-unit-level analysis within the banking industry, and firm-level analysis across multiple industries using the American Customer Satisfaction Index (ACSI) (www.theacsi.org). The ACSI is a firm-level assessment of customer satisfaction published quarterly by the National Quality Research Center at the University of Michigan Business School. Ittner and Larcker found customer satisfaction to be a modest leading indicator for various measures of Corporate Performance, including revenues, customer repurchase behavior, and stock price. Nowhere did they consider measures of customer satisfaction at the product level, much less at the level of the design of the product.

Customer satisfaction is typically treated as analogous to utility by the economics and accounting research domains. Lancaster (1979) and Bowbrick (1992) both hold that higher levels of customer satisfaction require higher levels of product or service attributes. This runs contrary to evidence from the evolution of PDAs. The success of Palm was not in maximizing the product attributes of previous generations of PDAs but in reducing the attributes to a level that was matched to the customers' needs more than the Apple Newton or Sony MagicLink. For Palm, the competitive advantage came not from improving all the attributes to maximize the utility of the product, but in the effective design of a reduced set of attributes designed to maximize the user's experience. This paper explores how the design bias of Product Social Capital provides the same leading indication of Corporate Performance by testing the following hypothesis:

> *Hypothesis: Product Social Capital is a leading indicator of future product revenues*

## 3    PRODUCT SOCIAL CAPITAL AND DESIGN CENTRIC PRODUCTS

In order to examine the potential of Product Social Capital to act as a leading indicator of Corporate Performance, the analysis includes four cases: two retro-designed automobiles, the Ford Thunderbird and the MINI Cooper and the PDAs from Palm and Handspring. These cases will be introduced below. Measures of Product Social Capital and Corporate Performance are also presented, with specific attention on the development of Product Social Capital metrics as applied to these four cases.

### 3.1    Palm OS Personal Digital Assistants

Christensen (1997) chose hard disk drives as his unit of study in the *Innovator's Dilemma* and refers to them as the "fruit flies" of the high tech marketplace. Like fruit flies, hard disk drives have short lifetimes and rapid cycles of introduction as compared to other products, such as airplanes and automobiles. Palm OS PDAs were selected as the first case for similar reasons. While Christensen focused on technologically-driven innovations, this study is focused on design-driven innovations. In design-driven innovations, what differentiates a particular product is not the novelty of the technology embedded in the product, but the configuration of maturing technology in a novel fashion that creates a compelling user experience. Personal Digital Assistants are high tech consumer products that experienced resurgence in the late 1990s after many fortunes were lost in the mid 1990s on pen-based computers and PDAs, such as Apple's Newton. It is interesting to note that there were no radical technological improvements driving this rekindled interest in PDAs. The success of Palm's first product was due to the improved Product Design of this PDA the prior generation.

Adoption in the PDA market may be a technology push for the early adopters, but the overall success of the market depends on customer pull (Burgleman and Sayles, 1986). The magnitude of customer pull relies on the strength of the relationship between the PDA and the end user. As a result of the impact of PDAs on the end user, millions of customers discarded their Franklin planners once they had a compelling user experience with the PalmPilot.

### 3.2    Nostalgia inspired automobiles : Thunderbird and Mini Cooper

The topics of design and automobiles have been deeply intertwined for decades. Much of the research effort in Engineering Design has focused on assisting automotive manufacturers build vehicles in less time, higher performance, and lower cost. In a period when new vehicle designs have many consumers yawning, automotive manufacturers are sifting through the archives and designing retro inspired vehicles. Volkswagen was the first to venture into the retro market with the redesigned

Beetle. Volkswagen's success with the Beetle sent other manufacturers scrambling to take advantage of the sudden interest in retro design automobiles. Ford and BMW used this strategy in the launching of the redesigned Ford Thunderbird and MINI Cooper. Ford reintroduced the Thunderbird for the 2002 model year after ceasing production several years prior. The MINI was first released in 1959 with the original design being discontinued in 2000, making way for a redesign of the MINI in 2002. This renewed nostalgia provides an interesting opportunity. When most consumers think of automotive design, they consider the lines of the vehicle and how it looks in their driveway. Yet design impacts much more of the consumer's experience with the vehicle than just the exterior appearance. By studying these retro-inspired vehicles, the impact of the aesthetics of the vehicle can be isolated from other aspects of design that impact the Product Social Capital of the vehicle. In working to understand why and how sales of the vehicles diverge, we can see what other design aspects of the consumer's experience contribute to the performance of these product lines.

### 3.3    PDA and Automotive Cases as Natural Experiments

Palm Computing and Handspring were two companies consistently leading the market in the early days of the Palm OS PDAs. These two companies were subjected to the same market conditions. Both were battered by the dot.com crash, yet survived with their market leadership intact. Both companies also had to compete with Microsoft's PocketPC platform. Jeff Hawkins and Donna Dubinsky founded both companies. The most visible distinction between these two companies is their product offerings. Handspring evolved a very different design language and feature set from Palm PDAs. The product lines remains distinct from each other even though the companies merged in 2003. The MINI and Thunderbird also represent a natural experiment. Both characterize the case of a large automotive manufacturer seeking to reap the benefits of the legacy these vehicle platforms had established. Both were launched in the same model year, within a month of each other. Although similar in design intent, it is interesting to note how differently these two cars have performed in the market. While MINI Cooper sales began small and have grown significantly since the product launch, Ford has experienced anemic Thunderbird sales. In fact, Ford announced that 2005 was the last model year for the new Thunderbird, citing dismal sales.

### 3.4    Measures of Corporate Performance

Many methods of accounting for Corporate Performance exist. Khatila (2002) used the enterprise's Return on Assets for her analysis of the global robotics industry. In his omnibus work, *Good to Great,* Jim Collins (2001) uses stock price as his performance metric in searching for companies that had made the transition from good to great. We use Gross Revenues as our metric of Corporate Performance in this study. Gross Revenues is the measurement of the financial capital generated by an enterprise through sales of products. Gross revenues can be viewed as more objectively product related than Market Capitalization. The stock price can be impacted by many subjective perspectives, such as a drop in NASDAQ performance or a sudden spike of interest in technology companies. In the case of Palm and Handspring quarterly Gross Revenues are available from routine public filings to the Securities and Exchange Comission. Monthly sales figures are used as surrogates for Gross Revenues in the automotive cases.

### 3.5    Online Customer Reviews as a Measure of Product Social Capital

After purchasing a product, a customer has many experiences regarding this product, both positive and negative. Web-based customer reviews provide an opportunity for users to share these experiences with others. These experiences define their relationship with the product and therefore define the Product Social Capital. At the lowest level of sharing, end users simply let their immediate circle of friends know of their experience. At the highest level of sharing, customers become product pundits, extolling the benefits or decrying the vices of their new product to anyone that will listen and even to others that do not listen. Malcolm Gladwell identifies these evangelists as "mavens," critical actors in moving a concept through its tipping point (Gladwell, 2001). Gladwell defines a tipping point as the point in the adoption of an idea, product, or service where the diffusion accelerates rapidly The evolution of the World Wide Web has given a new channel of communication to these mavens in the form of online customer reviews. These reviews can show up in the website of the product retailer (e.g., Amazon.com), so-called fan sites for products or classes of products (e.g., MTBReview.com), or

websites focused on gathering customer viewpoints (e.g., EPinions.com). Amazon.com has a rich collection of reviews, gathering comments from Amazon users on products ranging from books to diapers. In many instances, the customer did not even purchase the product through Amazon. These forums offer the customer a channel through which to comment on the benefit, or lack of benefit, the product brings to their life, the Product Social Capital. These reviews offer a resource for measuring the social capital inherent in the product as perceived by the population of users.

We have developed the measures of Product Social Capital using online customer reviews at Amazon.com for the PDA case and Edmunds.com for the automotive case. Amazon.com ratings are made on a five-point scale with the option for customers to leave comments about their experience with the product. Every review is time stamped. The review page contains a significant amount of information to aid customers in their purchase decisions. The average review for the product is displayed along with the total number of reviews. The individual reviews are preceded by a "usefulness rating." Then the summary, five-star rating is given along with a title for the review and the date the review was posted. This information is followed by the text review of the product.

There are many online sources for automotive customer reviews. Epinions, Yahoo Autos, Autobytel, and Edmunds all have an extensive collection of reviews for various automobiles. However, Edmunds.com has the most reviews for all model years of the MINI Cooper and Ford Thunderbird compared to the other automotive review sites, making it the ideal resource from which to extract Product Social Capital metrics. The customer reviews on Edmunds are similar in design to Amazon. The date and name/alias of the reviews are both recorded. Edmunds also allows website visitors to comment on the usefulness of the review for their own automotive purchasing decisions. Edmunds uses a ten-point rating scale instead of Amazon's five-star system. Consumers are asked to rate the vehicle across eight categories that are then aggregated into a single numeric rating by the individual customer. These categories are Performance, Comfort, Fuel Economy, Fun-to-Drive, Interior Design, Exterior Design, Build Quality, and Reliability. These eight categories are aggregated into one, non-integer rating for individual reviews, increasing the granularity of distinction between reviews and between products. The site solicits extensive information from the owner regarding their experience with the vehicle. Edmunds also asks customers to comment on their favorite features of the vehicle, along with any suggested improvements for future generations of the vehicle under review.

### 3.5.1 Exploring the Dynamics of Product Social Capital in Online Reviews

An initial assessment of all the reviews for the Palm Vx PDA reveals a pattern of reviews that is analogous to the diffusion of new products that Everett Rogers details in *The Diffusion of Innovation* (1995). The innovation diffusion curve consists of five stages. The first group to adopt a new product or idea is called the Innovators. The Early Adopters are next. Many new products falter with the Early Adopters. The Early Majority follows; people interested in the benefits but not in being first. In the Late Majority adoption begins to drop as the market becomes saturated. The last group is the Laggards, the last people to embrace the new idea. Though not measuring purchase activity, the frequency of comments does follow the curve of product adoption. The figure below shows the histogram of the comments fitted with a curve, which tracks with Roger's diffusion curves. The Palm Vx was released in October of 1999, providing a much needed memory upgrade to the popular Palm V. Still one of the most popular PDAs ever built, Amazon customers continued to offer their views on the Palm Vx for over a year after it was discontinued in March 2002.
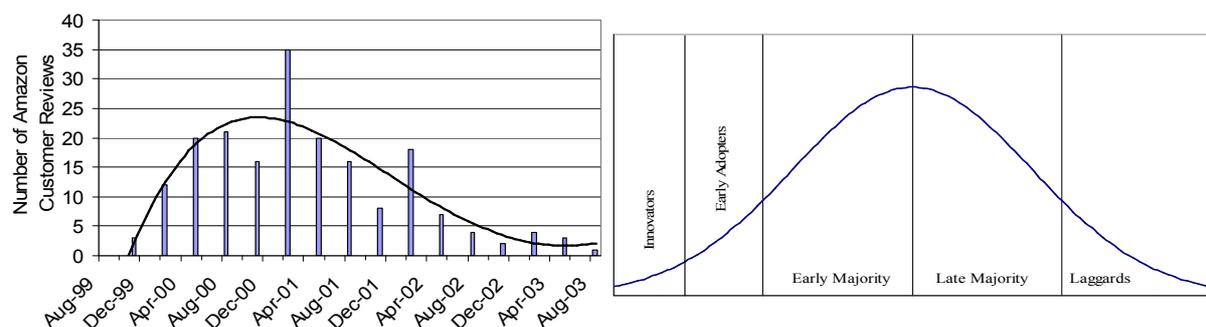


*Figure 1: Histogram of Palm Vx Social Capital compared to the innovation diffusion model*

This similitude to the innovation diffusion curve supports the use of the Amazon.com data to represent the acceptance of a product by the market as an innovation. The number of comments rises and falls in a manner analogous to the innovation diffusion model. Armed with this insight, there are two aspects of the Amazon.com reviews we can use to construct metrics for Product Social Capital. We can consider the frequency of comments and average comments over the period of assessment. The frequency of comments for the Palm case is represented by the number of customer reviews posted per fiscal quarter. The average review is taken as the average of all customer reviews during the fiscal quarter. As mentioned earlier, the frequency of new reviews rises and falls with the adoption of the product. The average customer review also changes over the product lifetime. The graph below illustrates how the average customer reviews decay over time for Palm PDAs. This trend is true for all the PDAs included in this study, indicating that Product Social Capital decays over time. This decay is indicative of an eroding relationship between the product and consumer.
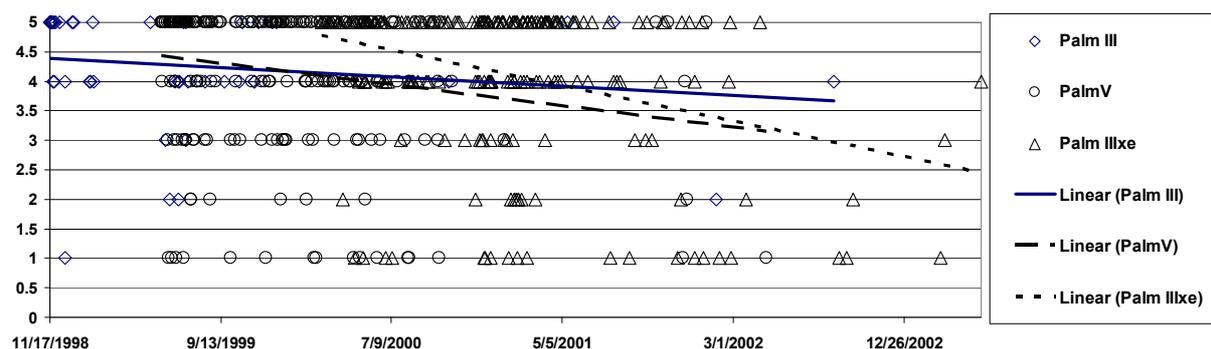


Figure 2: Plot of Amazon.com customer reviews for Palm III, Palm V, and Palm IIIxe.

Note that the linear fit for all three products has a negative slope, indicating a slow decay of Product Social Capital for each product. The Palm III has the slowest decay of these three popular Palm PDAs. The decay in Product Social Capital, despite an increase in customer utility could signal the erosion of the market and the entrance of a disruptive technology. Product Social Capital could provide further evidence of the creative destruction of markets by disruptive technologies.

### 3.5.2 Are the Amazon.com customer reviews really about design?
The Amazon customer reviews allow customers virtually limitless space to opine on the vices and virtues of the product or anything else they deem relevant. At first glance, you might think that the diversity of comments could include commentary on subjects beyond the product being reviewed. An analysis of all 232 comments by Amazon users regarding their experiences with the Palm V PDA confirmed that assertion. Each review is coded based on how its subject matter is classified in one or more of the following four categories:

- **Product Design:** Focuses on the core product and the features included in the original purchase.
- **Customer Support:** Comments on customer support, either of Amazon or the manufacturer
- **Product Accessories:** Accessories by third parties or the original equipment manufacturer
- **Third Party Software:** Software not included with the core device,

These four categories are distilled from a comprehensive review of all the comments. The comments are assigned categories based on the customer's general experience and defined according to the same criteria. The majority of the reviews mentioned the customer's response to the design of the product. Only one review does not mention the product and instead focuses on a nuance of a particular piece of third party software. Therefore, the customer reviews from these online websites accurately capture the customer's view of the benefit the product brings them. Because of the focus on Product Design, Product Social Capital can be measured using these online reviews.

### 3.6 Product Social Capital metrics for PDA's and Automobiles
The following graphs illustrate the Product Social Capital metrics used for this empirical study, which attempts to validate the use of the Comprehensive Design Engineering Framework. The two metrics utilized are derived from the Amazon.com customer reviews for Palm and Handspring PDAs. The

Average Amazon Customer Review measures the average review for all PDA reviews, of either Palm or Handspring products, for that fiscal quarter.
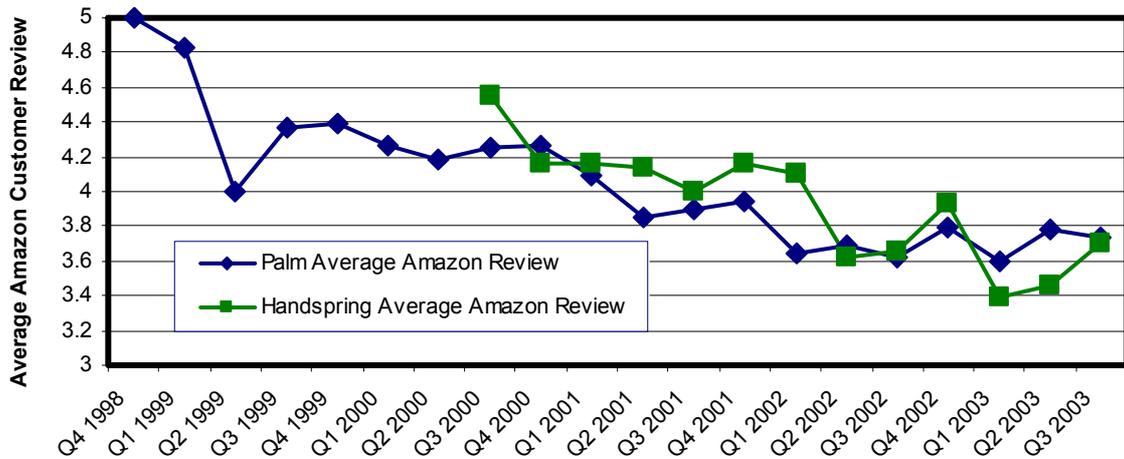


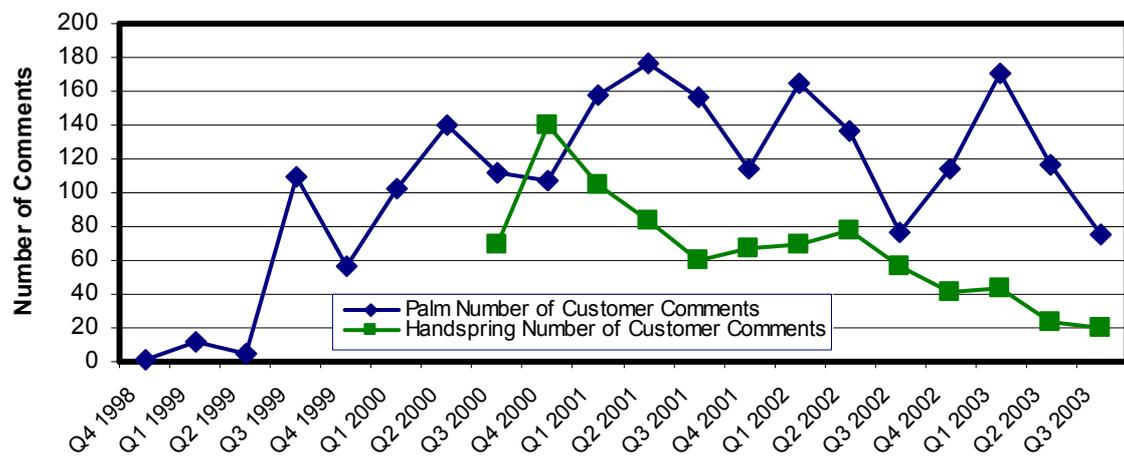Figure 3: Average Amazon.com Reviews for all Palm and Handspring Products



Figure 4: The Number of Customer Reviews per fiscal quarter for Palm and Handspring

Palm products had already taken the market by storm with the PalmPilot before Amazon.com started hosting customer reviews or selling products other than books. So the number of comments took some time to accumulate. Handspring comments did not appear until the launch of the first product, the Visor, in Q3 2000. Handspring comments tended to drop off toward the end of the study period as Handspring shifted product line focus to the Treo. A combination mobile phone-PDA, the Treo was initially only available through mobile phone service providers. Later versions of the Treo were available on Amazon as Amazon began offering T-Mobile service plans through its website, including plans that supported the Treo line of personal communicators. As the number of new customer reviews dropped, the average customer review increased, indicating that the new product offerings by Handspring were being well received by the market.

Both the redesigned Thunderbird and new MINI debuted in the 2002 Model Year. The Thunderbird was first released to the US market in September of 2001, and the MINI to the European market in October of 2001. This analysis makes use of data from the 2002, 2003, and 2004 model years, using reviews from Edmunds.com through July 2004. MINI comments seem to begin at the US introduction in March of 2002, even though the MINI was available in Europe during 2001. Consumers were still posting comments and reviews of their vehicle even after new models have been launched. The graph below shows the consolidated metrics for the Thunderbird and the MINI.
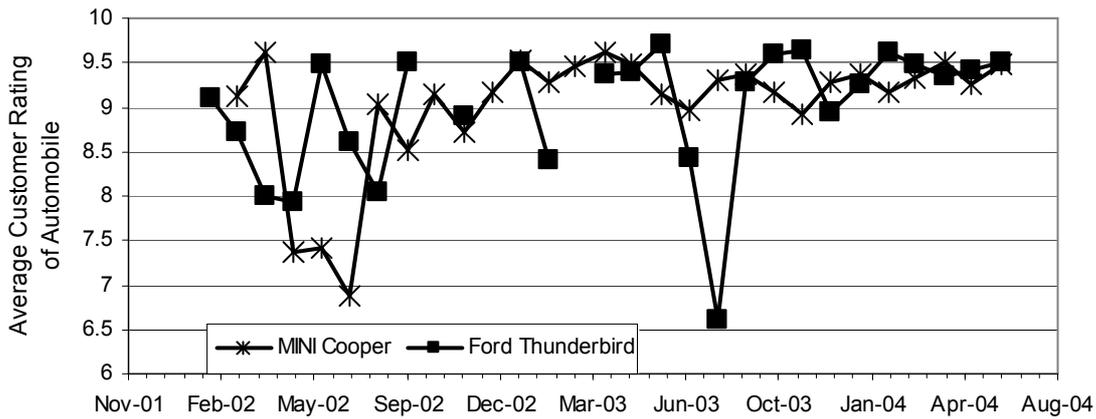
Figure 5: Average Customer Reviews by month for the MINI and the Thunderbird.

Figure 5 details the aggregated customer review data for the Thunderbird and MINI Cooper. It is interesting to note that as the number of model year vehicles available increases, the variation in the monthly reviews decreases, with the average review for both vehicles settling between 9 and 10. This could represent the consumer reaction to the initial variations in manufacturing and other aspects of the automotive experience. Later models are improved based on these initial units. The Thunderbird continues to have poor reviews until the release of the 2004 model year. The graph below details the monthly counts of customer reviews for the Thunderbird and the MINI.
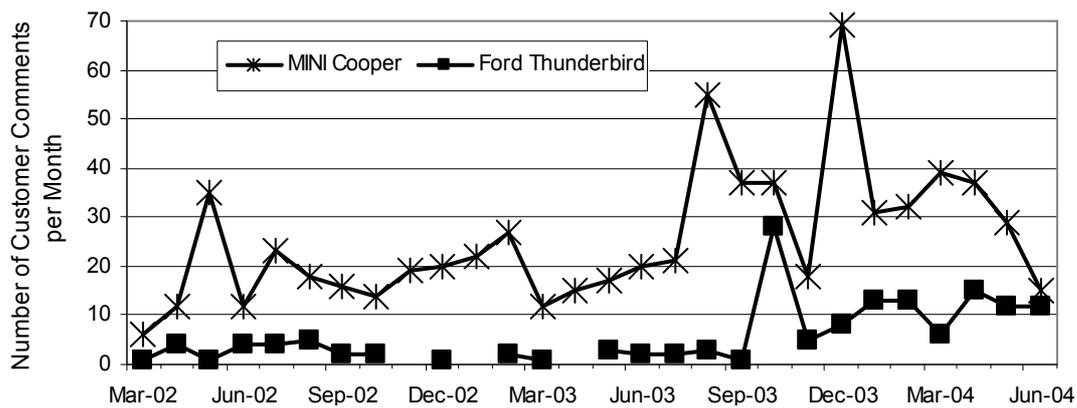


Figure 6: Number of new customer reviews each month for the MINI and Thunderbird.

The MINI Cooper has more customer comments than the Thunderbird for every month assessed. Both vehicles experience a significant spike in comments two years after their introduction, with an increasing number of reviews with time.

## 4    TEST OF HYPOTHESIS

Several statistical assessments can be used to assess the hypothesis that metrics of Product Social Capital consistently lead Corporate Performance. First, Pearson Correlations are calculated for each measure of Product Social Capital to understand how they relate to Corporate Performance for all four cases. The results of Pearson Correlations identify, for each of the four cases, instances where there is a statistically significant correlation to Corporate Performance. These results will then be used to create linear models using multivariate linear regression analysis. Those statistically significant, linear models are used to assess the validity of the hypothesis.

### 4.1    Examining leading trends using Pearson Correlations

In order to understand the nature of the relationship between Product Social Capital and Corporate Performance, a Pearson Correlation analysis is conducted for each of the four cases. This correlation analysis assesses how well the two classes of Product Social Capital metrics, Average Customer Review and Number of Customer Reviews Posted, linearly correlate with the respective Corporate Performance metric. In an effort to isolate leading behavior, the Corporate Performance measure is

sequentially offset by a number of time periods to see how the significance and strength of the linear correlation changes. The MINI and Thunderbird cases are led from zero to six months in the future. Palm and Handspring cases are led from zero to four fiscal quarters.

*Table 1: Pearson Correlation results for Handspring (*** p<0.01, ** p<0.05, and * p<0.10)*

| | Average Amazon Review for Handspring | | Number of Comments for Handspring | |
|---|---|---|---|---|
| | Pearson Correlation | Sig. (1-tailed) | Pearson Correlation | Sig. (1-tailed) |
| Gross Revenues | *0.494(**)* | *0.043* | *0.683(***)* | *0.005* |
| Leading 1 Qtr | *0.673(***)* | *0.008* | *0.894(***)* | *0* |
| Leading 2 Qtrs | *0.735(***)* | *0.005* | *0.700(***)* | *0.008* |
| Leading 3 Qtrs | *0.774(***)* | *0.004* | 0.285 | 0.212 |
| Leading 4 Qtrs | *0.825(***)* | *0.003* | *0.540 (*)* | *0.067* |

Results in bold are statistically significant correlations. Both Product Social Capital metrics consistently lead the Gross Revenues of Handspring. The influence of Average Amazon Reviews leading Gross Revenues by four fiscal quarters out has a correlation of 0.825. With respect to the Number of Comments, one quarter prior to current quarter has the highest correlation at 0.894.

*Table 2: Pearson Correlation results for Palm. (*** p<0.01, ** p<0.05, and * p<0.10)*

| | Average Amazon Review for Palm | | Number of Amazon Comments for Palm | |
|---|---|---|---|---|
| | Pearson Correlation | Sig. (1-tailed) | Pearson Correlation | Sig. (1-tailed) |
| Gross Revenues | -0.032 | 0.447 | *0.387(**)* | *0.046* |

As with Handspring, results in bold are statistically significant correlations. Only the Number of Comments correlates to Gross Revenues. The Pearson Correlation results are not as promising for Palm Computing. For Palm, the significant correlations are either concurrent or lagging Gross Revenues. There is a single positive and significant correlation for the current quarter of interest. The Number of Amazon Customer Reviews has a significant, positive correlation to Palm Gross Revenues in the current quarter. Neither of the Product Social Capital measures function as a leading indicator of Palm Gross Revenues. There is a potential that a linear regression analysis could find complementary relationships between the two Product Social Capital measures for Palm Computing.

*Table 3: Pearson Correlation Analysis of MINI. (*** p<0.01, ** p<0.05, and * p<0.10)*

| | Average Review for MINI | | Number of Reviews for MINI | |
|---|---|---|---|---|
| | Pearson Correlation | Sig. (1-tailed) | Pearson Correlation | Sig. (1-tailed) |
| Monthly Unit Sales | 0.233 | 0.117 | -0.121 | 0.27 |
| Leading 1 Month | *0.302 (*)* | *0.063* | *0.353(**)* | *0.036* |
| Leading 5 Months | *.389(**)* | *0.033* | 0.171 | 0.218 |

For the MINI Cooper we find several significant positive correlations for both the Average Customer Review and for the Number of Reviews posted each month. For the MINI, all the significant correlations also lead unit sales by one to five months, supporting the assertion that Product Social Capital is a leading indicator of Corporate Performance.

*Table 4: Pearson Correlation for Thunderbird. (*** p<0.01, ** p<0.05, and * p<0.10)*

| | Average Review for Thunderbird | | Number of Reviews for Thunderbird | |
|---|---|---|---|---|
| | Pearson Correlation | Sig. (1-tailed) | Pearson Correlation | Sig. (1-tailed) |
| Monthly Unit Sales | -0.136 | 0.254 | -0.185 | 0.168 |
| Leading 1 Month | -0.245 | 0.119 | *-0.317 (*)* | *0.05* |
| Leading 2 Months | -0.149 | 0.243 | *-.368(**)* | *0.029* |
| Leading 3 Months | -0.054 | 0.403 | *-.366(**)* | *0.033* |
| Leading 4 Months | 0.165 | 0.232 | *-.413(**)* | *0.02* |
| Leading 5 Months | 0.222 | 0.167 | *-.346(**)* | *0.049* |
| Leading 6 Months | *0.348 (*)* | *0.067* | 0.016 | 0.471 |

The only positive correlation by Average Customer Reviews comes six months prior to the month of interest. The other significant correlations are negative and leading by one to five months. The negative correlations are all clustered in the Number of Customer Reviews. These results indicate that

the more customers commented on their Thunderbirds, the less Ford sold in the ensuing months. The only case where more comments did not correlate to lower sales was six months prior with the significant positive correlation to the Average Customer Review. Further linear regression analysis will explore the shared influence of both Product Social Capital measures on monthly unit sales.

All four cases resulted in at least one positive correlation. Three of the four cases showed evidence of the utility of Product Social Capital as a leading indicator of Corporate Performance. The Ford Thunderbird case had significant negative correlations to monthly unit sales. This analysis was limited to assessing only one Product Social Capital measure to Corporate Performance at a time. In the next section, we will make use of linear regression analysis to explore the simultaneous relationship of both Product Social Capital measures with Corporate Performance.

## 4.2   Multivariate Linear Modeling Product Social Capital as a Leading Indicator

The Pearson Correlation is effective in understanding how the Product Social Capital measures correlate to Corporate Performance. The correlation analysis is limited to one dependent variable (Corporate Performance) and one independent variable (one of the Product Social Capital measures). In order to understand how the combined Product Social Capital measures correlate to Corporate Performance, a multivariate linear regression analysis was done for the instances in which significant Pearson Correlations exist. For the PDA's, models are generated using Gross Revenues as the dependent variable at time shifts of zero to four fiscal quarters. The automotive cases analyze unit sales shifted in time from zero to six months. Significance levels of $p<0.10$, $p<0.05$, and $p<0.01$ are included in this analysis. Linear models with statistically significant results are included.

*Table 5: Summary statistics for all Handspring linear regression models.*

| Lead | R | R Square | Adjusted R Square | Significance | Predictors for Handspring |
|---|---|---|---|---|---|
| 0 | 0.683 | 0.466 | 0.417 | 0.010 | (Constant), Number of Cust Reviews |
| 1 | 0.894 | 0.8 | 0.779 | 0.000 | (Constant), Number of Cust Reviews |
| 2 | 0.854 | 0.73 | 0.662 | 0.005 | (Constant), Average Cust Review, # of Cust Review |
| 3 | 0.774 | 0.6 | 0.549 | 0.009 | (Constant), Average Customer Review |
| 4 | 0.825 | 0.681 | 0.636 | 0.006 | (Constant), Average Customer Review |

Every case tested for Handspring results in a positive and significant linear model of Gross Revenues. The model where the Number of Amazon Comments led Gross Revenues by one quarter has the highest correlation. The next best model leads both Product Social Capital measures by two quarters. For the models leading Gross Revenues from one to four quarters, our metrics correlate to over 50% of the variations in Gross Revenues. The Handspring case strongly supports the hypothesis.

*Table 6: Summary statistics for Palm Computing.*

| Lead | R | R Square | Adjusted R Square | Significance | Predictors for Palm |
|---|---|---|---|---|---|
| 0 | 0.387 | 0.15 | 0.103 | 0.092 | (Constant), Number of Cust Reviews |

Palm is an enigma within the four cases analyzed for this study. Only one instance produces a significant linear relationship. This model demonstrates a contemporaneous relationship between an increased number of customer comments on Amazon.com and Palm quarterly Gross Revenues. As such, the Number of Customer Reviews posted in a quarter can explain 10.3% of the variation in Palm Gross Revenues. This case does not support the hypothesis.

*Table 7: Summary statistics linear regression Models for MINI Cooper.*

| Lead | R | R Square | Adjusted R Square | Significance | Predictors for MINI |
|---|---|---|---|---|---|
| 1 | 0.353 | 0.124 | 0.089 | 0.071 | (Constant), Number of Cust Reviews |
| 5 | 0.389 | 0.151 | 0.111 | 0.067 | (Constant), Average Customer Review |

Of the seven instances tested for the MINI Cooper, only two result in significant linear models. The model of Product Social Capital leading unit sales by one month indicates a positive relationship with an increased Number of Customer Reviews. A similarly positive relationship is found when the

Average Customer Review leads monthly MINI sales by five months. This model results in the highest correlation, indicating that this model explains 11.1% of the monthly MINI sales with a 93.3% certainty. The case for the MINI Cooper supports the hypothesis.

*Table 8: Summary statistics for Ford Thunderbird linear regression models.*

| Lead | R | R Square | Adjusted R Square | Significance | Predictors for Thunderbird |
|------|-------|----------|-------------------|--------------|----------------------------|
| 1 | 0.368 | 0.136 | 0.098 | 0.070 | (Constant), Number of Cust Reviews |
| 2 | 0.399 | 0.159 | 0.121 | 0.053 | (Constant), Number of Cust Reviews |
| 4 | 0.406 | 0.165 | 0.123 | 0.061 | (Constant), Number of Cust Reviews |
| 7 | 0.439 | 0.193 | 0.146 | 0.060 | (Constant), Average Customer Review |

The Thunderbird models are significant to the $p<0.10$ level; there is 90% chance a particular model represents a real relationship. Instances leading one, two and four months all resulted in significant models using the Number of Customer Reviews as the leading indicator. These models have a negative correlation to monthly Thunderbird sales. An increase in customer reviews correlated to a downstream decrease in sales. The model with Average Customer Reviews leading by seven months correlates to increased Thunderbird sales. This model also has the highest correlation, supporting the hypothesis that Product Social Capital is a positive leading indicator of Corporate Performance.

*Table 9: Summary statistics for Palm Computing.*

| Lead | R | R Square | Adjusted R Square | Durbin-Watson | Significance | Predictors for Palm |
|------|-------|----------|-------------------|---------------|--------------|---------------------|
| 0 | 0.387 | 0.15 | 0.103 | 1.113 | 0.092 | (Constant), Number of Cust Reviews |

Palm is an enigma within the four cases analyzed for this study. Only one instance produces a significant linear relationship. This model demonstrates a contemporaneous relationship between an increased number of customer comments on Amazon.com and Palm quarterly Gross Revenues. As such, the Number of Customer Reviews posted in a quarter can explain 10.3% of the variation in Palm Gross Revenues. This case does not support the hypothesis.

## 4.3   Results of testing Hypothesis

Three out of four cases support the stated hypothesis that *Product Social Capital is a leading indicator of future product revenues*. This is strong evidence that good design, as indicated by Product Social Capital measures, correlates with future product sales. The two types of cases are different in their units of study. The MINI Cooper and Thunderbird cases focus on one product line with the context of a larger enterprise. The Palm and Handspring cases include all products aggregated into a single measure for each firm. MINI and Thunderbird provide support of the hypothesis for individual products and Palm and Handspring provide support at the firm level. At both the level of the firm and of the product, the strength of the relationship between the end user and the product, as measured by Product Social Capital, is a leading indicator of future revenues. Design teams are responsible for ensuring this relationship is a healthy one and have a measurable impact on corporate performance.

## 5   CONCLUSION

Using Product Social Capital to measure the strength of the relationship between the end user and a well design product correlates strongly to enterprise performance. In the cases presented here, good design, as measured by Product Social Capital, can act as a leading indicator of downstream revenues. Design teams that focus their efforts on building and supporting a strong relationship between the product or service and the end user have increased odds of outperforming their competitors. Additionally, the decay of Product Social Capital over time supports the need for firms to refresh the design on an ongoing basis to maintain a high level of Product Social Capital. Further work is necessary to develop the methods to assess and improve Product Social Capital during the design process. This extends beyond requirements engineering since much of the experience that constitutes the relationship measured by PSC can only be assessed when there is sufficient concept maturity to allow the end user to have a significant experience with the nascent product. Only then can the design team validate or disprove assumptions as to how the requirements track to the user experience and

adjust the design and system requirements accordingly. These results support our belief that good design is good business.

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