What You See is not What You Get:

Product Architecture and Corporate Strategy

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Weaving insights from the study of technology, operations, and organizational theory, we examine factors that underlie decisions about product product architecture. The general principles that determine the composition and interdependency between the components that make a product have largely been relegated to the engineering literature. However, our preliminary results from a Wharton-SMU study of product architecture in the imagining industry suggest several overlooked factors that play an important role in determining product architecture and consequently – firm performance. We suggest that product architecture decisions are far from being the exclusive domain of engineers. Using a sample of firms and products from the imaging sector, we distinguish between the engineering product architecture and perceived product architecture and note that they can be decoupled. Second, we seek to determine how firm choices regarding the design architecture can be mapped explained using variables such as firm prestige and customer sophistication.

Keywords: Product Architecture, Strategy, Cognition,

The literature on product architecture[1] has progressed to create a universal language describing the principles that guide product design. It identified four product architecture archetypes – *integral*, *slot*, *bus*, and *sectional* – that can be used to describe almost any product, however humble or complex it may be (Ulrich, 1995). Those archetypes differ on the degree of interdependency of components and how they relate to each other. For instance, in *integral* design, such as that of a disposable ballpoint pen, all of the components fit tightly and idiosyncratically with one another. The product is self-contained, its parts are highly interrelated, and the entire design is tightly coupled. Such design has some advantages: it can simplify manufacturing processes, it presents the consumer with neatly packaged product, and it makes it difficult for competitors to offer after-market or add-ons. The biggest drawback of such design lies in its inhospitality to change. At the component level, because they are tightly related, even a minute change in the design of one component will require a review and possible change in all of the other components. Organizationally, that review and possible change has commensurate repercussions on the way people inside and outside firm align their activities. The interfaces may be mapped onto the design of the firm and determine the interdependencies among its parts. The interdependencies need to be coordinated and whenever the design architecture becomes transformed, so does the corresponding repertoire of coordination routines (compare Christensen and Rosenblom, 1995)

In *bus* design, the second design archetype we will discuss here, all the components fit into a central interface that connects them to each other. While the connection to the bus may be idiosyncratic, the components co-function without being connected directly to each other. Rather, they all connect to the bus, not to each other. Thus, a removal or addition of a component does not

[1] Management scholars have discussed general principles of design for quite some time, covering not only physical products, but also such institutions as contracting and government (Baldwin & Clark). Our usage here is congruent with that common in the engineering and operation literature, where scholars speak of "product architecture" (Ulrich). Both usages are different from the common use of "design", which has to do with the choice of such characteristics as shape and material. They are also unlike the common use of architecture, which has to do with construction style.

require a redesign of the entire product. Hence, for instance, one can remove a hard drive from a desktop computer and replace it with a DVD drive. While the two components are different, they are identical in the way they connect to the computer bus and interact with the other components, such as the central processing unit and memory. Similarly, one can disconnect a set of speakers from a high-end stereo amplifier and replace them with other speakers without making any changes to the amplifier or the other components in the system. As long as the new speakers feature the same interface as the prior ones, their other characteristics as irrelevant to the functioning system. Bus design is *not* an entirely modular design, because each component must be connected to the bus through a specific interface. Components that do not feature that interface cannot be connected to the system. For instance, speakers that feature an optical interface, where sound data are transmitted through pulses of light, cannot be connected to an amplifier that does not feature such interface. Just like any design archetype, bus design has its merits and drawbacks. For one, it allows for greater flexibility in customization of a product. By stocking just few alternative components, a computer manufacturer can offer a great variety of combinations of hard drives and DVD drives, for instance.

Finally, *sectional* product architecture is based around complete modularity, where components can be added or removed freely, in a Lego-like manner. Such would be the case with a modular shelving system that can accommodate shelves of various lengths and width or stacks of drawers or filing cabinets, or a combination thereof. While few products are belong purely to one category, it is useful to perverse those categories for analytical purposes.

Students of technology have long been aware of the vast implication of product architecture choices, and have engaged in a lively discussion on the proper fit between products or services and their architecture Sako (2004, 2005) among others has been prominent in examining the architecture of products and services, and the challenges they entail when firms seek to partially outsource the design or production of certain components. As one may expect, however, this literature has maintained a strong engineering focus and rarely ventured beyond consideration of product function and costs associated with sourcing, manufacturing, and servicing into such considerations as strategic and organizational considerations as product differentiation or organizational. design. Our data on the evolution of the imaging industry, supplemented with data from consumer electronic products, suggest that a taking broader view produces new strategic insights.

What has largely escaped discussion is the notion that product design can have important competitive consequences. The bus archetype has been hailed for its advantages in simplifying the engineering process and allowing product customization at lower cost. However, its unheeded adoption can have detrimental consequences for corporate strategy. This is because it allows users to purchase add-on components or swap original components, thus reducing the original manufacturer stream of revenue and potentially compromising product integrity.

This hazard is epitomized in products that derive profits from the Razor Blade model, allegedly invented by King C. Gillette, where the initial product may be sold at a low profit margin, but guarantees a stream of profits from selling high profit margin replacement parts (Tripsas & Gavetti, 2000; Wikipedia). In the Gillette case, it meant selling low cost razors and profiting from the high margins obtained on the replacement razors, without which the product quickly becomes useless. Another example is printer ink cartridges, which, just like razor blades, require periodical replacement. Because cartridges are connected to the printer in a discernable interface, third party manufacturers have been able to offer alternative cartridges that fit in the printer just like those made by the original manufacturer. By purchasing from such alternative sources, consumers can circumvent the Razor Blade model and undermine the manufacturer strategy. So high are the stakes around such strategy that the introduction of third party components has led to an on-going series of legal challenges, which focus on whether the manufacturing of such add-on product infringes on the copyright on the original designer. So far, US courts have denied the claim (e.g. , "Lexmark International, Inc. v. Static Control Components, Inc.").

Whenever a sector becomes increasingly modular in the mode in which products converge towards certain standards the more compelling it becomes for manufacturers to settle on architectural competencies while leaving the development and production of components to strategic partners. The implication is that firms ought to accumulate design skills and social capital to build a network of firms held together by long term, trust based alliances.

We argue that advantage of integral design emanates not only from the engineering considerations noted above, but also from the place such design occupies in consumers' mind. Our data suggest that unsophisticated consumers prefer integral product architecture. Firms could reap rewards from combining perceptual advantages the appearance of integral design with the manufacturing advantages bus (or sectional) design. A challenge for firms is to design and produce a modular architecture that notwithstanding its sectional properties has an integral appearance in the market place.

We use *Janus-faced*, after the Roman deity *Janus*, to describe the two contrasting aspects of products that simultaneously possess an appearance of integral product design while their engineering underlying are based on bus (or sectional) product design. The process of production does not necessarily signal the way buyers ought to observe the properties of a product. Questions we should address include the matter of customer perception of product architectural design (compare Winter, 1984 on technologies that can be observed and those that are hidden to "outsiders."). Some technologies, such as open source innovation (von Hippel & von Krogh, 2003), are highly visible and become shared among the participants (Levine, 2001), while others are proprietary, cloaked trade secrets and by tight intellectual property arrangements.

Method

While we developed understanding of the role product architecture plays in engineering and operations, we know less about its potentially important role in firm strategy, including its effect on firm status or the way it affect consumer perception. The rarity of previous research and the lack of firm theoretical framing have led us to adopt qualitative research methods, which are more appropriate for the inductive development of theory, when meaning, process, context, and unanticipated phenomena are uncovered and explained (Glaser & Strauss, 1967; Strauss & Corbin, 1990). Qualitative methods are suitable for theoretical development, as they may lead to the discovery of a novel construct or unknown link between existing constructs.

Following the qualitative research method literature, we chose a maximum variation sampling technique (Guba & Lincoln, 1989; Maxwell, 1996). In this configuration, a researcher specifically chooses sites that are likely to be quite different from each other, in order to use the variance for generating rules about the relationships between variables. We have done the same by sampling multiple industry sectors. We also collected data in multiple industry sectors, several countries and geographical regions, and across positions and hierarchical ranks. This wide and exploratory effort allowed us to discover the contingent framework that we present here.

Choice of Sites

We were drawn to two industries that evolved rapidly in recent years, because of our interest in industry evolution (results reported elsewhere). Hence, we chose to focus on photographic equipment. We also use a case from of a mobile music player (also known as MP3 players, after the compression algorithm implemented in them). The photographic equipment industry has undergone a fundamental shift as the image-capturing medium has evolved from analog (film) to digital (charge-coupled device or CCD). It has been apparent not only in consumer-grade equipment, where digital cameras have reached complete domination, but also in professional, military, and medical applications. A similar shift has taken place in the market for mobile music players, where the media have shifted from analog (e.g. cassette-based Walkman) and optical (compact disk player) to memory and hard disk based devices. Prominent in this market is Apple iPod, who commands a 75% market share (Wingfield, 2006), which we used to demonstrate the generalizability of our ideas.

As commonly done in qualitative research, we began collecting data in an exploratory mode: with interest in product architecture but without specific hypotheses, as to allow hypotheses to emerge from the data. To allow for within-firm variance and to increase inter-site reliability, we designed the study using a qualitative *maximum variation sampling* approach, which prescribes sampling from potentially different sub-populations in order to identify differences and increase inter-site reliability (Guba & Lincoln, 1989; Maxwell, 1996). We achieved that by collecting data in multiple industry sectors, several countries and geographical regions, and across positions and hierarchical ranks. This wide and exploratory effort allowed us to discover the contingent framework that we present here. To allow for cross-validation, we employed not only single interviews, but also a variety of other data collection tools, such as repeated interviews, document analysis, and informal conversations (Maxwell, 1996). The preliminary data reported here was collected in five months, during which we conducted dozens of interviews, visited company locations, and attended industry conference and seminar. Field notes about observations and informal interviews extended over dozens of pages.

Insert Table 1 about here

Following established methods of grounded theory development, the study was conducted in four phases, from preparation to theory building (Glaser & Strauss, 1967; Miles & Huberman, 1984; Strauss & Corbin, 1990). In the pre-study phase, we prepared by reading industry trade journals, articles in the business press, academic and case studies about the industry. We spent time identifying and contacting informants. To increase variance in qualitative sampled, we approached a variety of informants. We called on engineers, chief executive officers, industry experts, and journalists. We presented our interest and research plan, and asked whether they would be interested in cooperation. As those confirmed their willingness, we deepened our understanding of the firms involved by reviewing a variety of information sources, such as press articles, financial reports, and sales materials.

Phase One: Fieldwork

Phase one consisted of data collection in the field, using interviews, repeated interviews, document analysis, and informal conversations.

Informant Recruiting

Following the maximum variation sampling design, we recruited informants through several channels. First, we used our familiarity with the industry and approached some informants directly, contacted them by telephone and requested and requested a meeting. Once we recruited an informant, we asked her or him to introduce us to their colleagues, supervisors, and subordinates, if appropriate. Second, we scanned our institutional database to identify alumni employed in the focal industry. Third, we approached some informants based on referrals from our acquaintances or other informants. Fourth, we attended a large industry conference and seminar, where we approached and recruited informants.

We believe that the combination of sampling approaches – direct request, database, snowball, and on-site – helped to limit selection bias in the interviewee population (Maxwell, 1996; Miles & Huberman, 1984; Strauss & Corbin, 1990). A request to meet was denied only once, when we approached a contracting manufacturing firm.

Interviews

Interviews were open-ended, moderately directive, and mostly aimed at producing a fine-detailed description of activities in the informant professional area. The only exception was the series of interview of a veteran journalist, where we used his expertise to discuss specific industry occurrences and trends. Commonly, interviewees described a process they were involved in, such as the selection of equipment for procurement, the development of a new model, or the contracting of a sub-component. Since we were interested in product architecture, we probed related issues, but only if those surfaced during the interview. For example, to elicit a detailed account, we sometimes asked the interviewees about a specific occurrence they took part in, and ask them to take us through the entire process. Then, if a relevant occurrence was mentioned (e.g., "We decided to outsource development and production of our lenses to a lens manufacturer"), we would ask further about it using nondirective terms (such as "Can you take us through how the decision was made?" or "Would you tell us more about it?"). In other cases, we had previous knowledge that the interviewee had had a relevant professional experience, e.g. was involved in the development of a first digital camera. We then encouraged them to give a thorough account of the experience, starting from the very moment they began to work on it and ending in the present.

Interviews lasted between thirty minutes and two hours, with an average of an hour per interview. Most of the interviews were recorded; minority of them was documented through extensive field notes that were elaborated after the interview. In line with ethical standards of informed consent (American Sociological Association, 2001), we reiterated to the informants that the meeting was voluntary, assured that the discussion would be kept strictly confidential, and asked for permission to record it. In no interview has an interviewee requested to stop recording.

Observations and Informal Conversations

We collected data not only through interviews but also through informal conversations. This was the major method for data collection when we attend two industry events, part of the industry's main trade show, which we were invited by two of the informants. Together, we spent roughly 33 hours collecting data informally. We arrived to the tradeshow grounds in early in the morning's hours and spent there at least eight hours daily, until it was closed for the night. We scheduled one or two formal interviews a day, leaving most of the time for informal interactions.

We engaged in conversations with attendants and exhibitors, recruited informants, and collected documents, which were later analyzed. We took field notes recording such informal discussions and observations, as well as documents we read. We took notes and recorded artifacts with a digital camera, using those as data points in the subsequent analysis. Speaking informally, without recording or visibly taking notes, allowed us to converse in a more relaxed atmosphere and confirm things we heard in the interviews. It also provided leads into data and events that were not mentioned in the interview because we simply did not know to ask about it.

Compared to other researchers who spent their entire study on one site, we chose to collect data in multiple sites sequentially. Interviews took place in three European countries and in the United States. This was a natural outcome of our decision to maximize variance sampling, and it enables us to make an argument about the industry, rather than about a specific firm or firms in it.

Phase Two: Interpretation

In phase two, we developed a formed interpretation of the data. Most of the interviews were recorded were recorded and then transcribed by an assistant or us. In addition to the transcription, we used the recording to assure accuracy and add information about voice tone and conversational pauses (Weiss, 1994). To the body of the interviews, we added our notes about the interviews. The field notes, detailing observations and informal discussions, were also typed. In addition, we collected evidence from documents of and about firms and the industry, as described earlier.

Analysis of the data began almost as early as we embarked on the data collection effort. Using qualitative analysis software (Bazeley & Richards, 2000; Burgess, 1995), we carefully examined each datum and assigned it to several categories. Data were coded shortly after they were entered. As data accumulated, we often refined categories by splitting them into sub-categories and recoding the data into those categories. For instance, a category initially called "difficulty in moving from analog to digital" was split to indicate whether the difficulties were the result of engineering setbacks or of consumer perception. The quick growth of latter sub-category has led us to look in greater depth of those instances, which eventually led to the identification of the strategic role played by product design.

The process of coding data continued throughout the months of fieldwork and grew in intensity in the hiatus between periods of fieldwork. As evidence accumulated, phenomena were linked into patterns, and those were linked together in a framework. As data amassed, we kept updating the framework by adding, dropping, and tweaking it.

Phase Three: Validation

In phase three, we worked to increase validity and reliability by presenting an early version of the findings to informants and industry experts. We discussed the findings with industry observers and other researchers who worked on similar topics. The discussions with key informants revealed few errors in the data we used. The reactions we observed suggested that the findings were neither obvious nor universally present in firms. While the qualitative nature of the data limits claim to generalizability, we believe that the risk of invalidity is low, given the breadth and variance of the sample, the crosschecking of interviews, informal conversations and observations, and the feedback in the validation phase.

Findings and Analysis

First, we use the case of Apple's iPod to demonstrate how firms can decouple perceived design from engineering design, using a Janus-faced design architecture, which satisfies lay consumers' preferences for integral design while reaping the benefits of bus or sectional design. Second, we show that similar products can be built using markedly different product architecture, by using data from our investigation of camera makers. We then proceed to hypothesize that firm choice of architectural design can be mapped to the degree of sophistication of its consumers as well as its place in the industry's status hierarchy.

Janus-faced product architecture. To illustrate the nature of Janus-faced product architecture, we turn Apple's iPod, a mobile music player. When debuted in 2001, the 6.5-ounce, stainless steel device, which was about the size of a deck of cards, could carry 1,000 digital recordings on its five-gigabyte hard drive. Apple heralded it as the "unveiling of a breakthrough digital device", a claim that was met with skepticism with industry observers, as the marketplace for such players was already crowded with offerings from other companies (Pogue, 2001). Financial analysts warned that Apple might be erring by venturing into the low-margin consumer electronics business and conjectured that the main contribution of the iPod would be in driving sales of the company's Macintosh line of computers (Tam, 2001).

Five years later, the iPod has become the subject of numerous admiring articles in the managerial and popular press, described in such terms as "innovative" (Yoffie & Slind, 2006) or a "perfect example" of "breakthrough offering" (Silverberg, 2005). Jack Walsh, the former executive chief or General Electric has used the iPod example to preach the virtues of American innovation to foreign audiences (Jin-Seo, 2006). Further, the iPod has arguably become an icon, whose influence is described in the popular media to possess "fanatical devotion", it is said to spun its own economy with "companies that cater to the faithful" and create cultural trends (della Cava, 2005). Indeed, the iPod influence has been described in gargantuan terms: "the iPod has changed our behavior and even our society. It has transformed Apple from a computer company into a consumer electronics giant. It has remolded the music business, altering not only the means of distribution but even the ways in which people enjoy and think about music. Its ubiquity and its universally acknowledged coolness have made it a symbol for the digital age itself, with commentators remarking on 'the iPod generation'"(Levy, 2006).

Given its status, it is surprising that almost none of iPod components are produced or even designed by Apple. A close inspection reveals that Apple assembled components that are generic, licensed or have been available in the marketplace for a while. Although the specifics of Apple relationships with its suppliers are closely guarded by the company, independent reviews suggest that the iPod processor is produced by Portal Player while its operating software is licensed from Pixo. The tiny hard disk that lies in the heart of the product is made by Toshiba, the battery is sourced from Sony and other manufectures, and the liquid crystal display is said to be made by LG, a consumer electronics maker, as well as other manufacturers. One of the few components made or designed by Apple is the FireWire bus, which interfaces data transfer between the disparate components (Day, 2005; Walker, 2003).

Insert (iPod architecture scheme) about here

Why do consumers view a collection of outsourced components as "sleek" or "elegant", perceiving it to be a culturally and economically transforming invention? We suggest that while architecturally it is clearly based on bus design, the iPod is perceived as product that features integral design. Hence,

H1: The perception of product architecture can be decoupled from its engineering architecture

Decoupling design from perception is a significant achievement, because the ability of a firm to infuse its products with an integral identity hinges very much on the degree to which the requisite structures themselves -- internal or external -- are seamless (Henderson & Clark, 1990). If the relationship between the makers of the various components that go into a product are not seamless the consumer is likely to see them as being uncoupled and perceive its performance to be deficient.

This is true because firms can manufacturer the similar products using markedly different designs. We elaborate on that in the next section.

Choices of product architecture. We now turn to our data on the product design of products in several segments of camera manufacturers to show how similar products can have markedly different product architectures. Every camera, regardless of its technological sophistication or price level, contains three basic elements: 1) lens, which focuses the light on the 2) capturing device, which can be film holder or digital unit (CCD), and an 3) enclosure that houses these two elements together with other optional elements, such as light meter or strobe (flash). This structure has remained unchanged from the *Camera Obscura* of the 1700s to the high-end professional digital cameras of the present.

Insert (camera scheme) about here

These components are universally present in cameras. Naturally, their specifications differ according to the use of the camera. Most importantly for our purpose, the product architecture of a camera can range fro integral to sectional. Many simple point-and-shoot cameras contain all of the elements in a single, compact enclosure. When a consumer purchase a camera, she buys a bundle of a lens, capturing device, and an enclosure, all usually carry the same brand name. As expected in integral design, the components are tightly related, and one cannot replace the lens without replacing the entire camera. Bus architecture in camera design is exemplified in a single-lens-reflector (SLR) camera. These cameras, larger and more expensive, decouple the lens component from the other components. Therefore, a consumer can purchase just a "body", i.e. an enclosure that includes a capturing device. Then, depends on the intended use of the camera, the purchaser can choose from a variety of lenses, such as those intended for landscape, wildlife, or portrait work. The lenses are made by the camera manufacturer or a number of independent makers, purchased separately, and connect to the camera body through an electronic data connection, i.e. a type of bus, which transmits data between them.

Finally, sectional architecture in camera is exemplified in professional grade cameras. Known as medium-format and large-format cameras, and used in photography studios and other commercial applications, these cameras allow user to replace the lens and capturing device as necessary, swapping and matching a lens, capturing media, and a camera body as needed. Thus, for instance, a user can combine lens suitable for portraiture and capture the image on black and white film, and instantaneously swap these components to lens suitable for close-up image and capture the image digitally.

We use cameras to demonstrate how a given product can appear in several product design architectures. Point-and-shoot cameras follow integral design, single-lens-reflector cameras follow bus design, and medium/large format cameras follow sectional design. As the iPod case demonstrated, firms can decouple a product's perceived design from its engineering design. Hence, firms have a decision space to determine how a product should be engineered and how it should be communicated to consumers. What determines those decisions? In addition to engineering considerations, we hypothesize that they are dependent on consumers' preferences and on the firm's status.

Consumer Preferences and Firm Status. Different architectural designs are preferred by consumers groups that are distinguished by their degree of sophistication. While lay consumers gravitate towards the simple products of integral design, hobbyists and professional prefer the flexibility and customization possibilities associated with bus and sectional design.

<u>H2a</u>: The *less* sophisticated a consumer segment is, the greater the preference for product architecture that is closer to *integral* design.

<u>H2b</u>: The *more* sophisticated a consumer segment is, the greater the preference for product architecture that is closer to *sectional* design.

Next we turn to the concept of firm status to inform about the ability of firms to achieve product integration at high quality as communicated through status, whether legacy or current. Low status firms face unfavorable production functions and endure negative channel dynamics while high status firms cannot only produce more cheaply but also charge premia for their output. They also face the threat of status leakage when they transact with low status firms. Polodny (2005; , 1993) argues that interaction between unequal actors affect both sides' status. While the lower-status actor benefits from being associated with a higher-status actor, the latter suffers decreased status from such interaction. Hence, high-status actors seek to limit such interaction, while low-status actors seek it.. We apply this logic to argue that the higher a firm's prestige, the greater its ability and the lower the threshold for achieving a high degree of architectural integration with a strong sense of product unity. We hypothesize that high status firms will seek avoid association with lower status firms, and will labor to create a perception of integral design, even if their product is bus (or sectional), as in the iPod case. In contrast, low status firms will seek association with higher status firms by including components and will gravitate towards bus or sectional design. This leaves as undesirable the combinations of low firm status-integral design and high firm status-sectional design.

H3a: When facing a combination of lay consumers and high status, a firm will perform better in gravitating towards integral design.

H3b: When facing a combination of sophisticated consumers and low status, a firm will perform better in gravitating towards sectional design.

Insert Table 2 about here

A profound paradox exist in the quest for a market preference for integral design and a, coordinative, efficiency based sectional design. On the one hand, we posit a presence of market segmentation along the dimension of customer sophistication and product perception from integral to sectional. On the other hand, we argue that firms can be arrayed along a dimension of status ranging from low to high prestige (J. M. Podolny, 1993) (Roberts, 1998; Podolny, 1993). The challenge of firms to achieve product offerings that match the consumers preference for integral designs is paradoxical since sophisticated or knowledgeable customers, such as lead users (von Hippel, 1986, 2005) prefer sectional over integral designs. Lay, i.e. naïve and unsophisticated consumers prefer integral designs. By contrast, high status firms who are expected to target knowledgeable consumers, lean towards product architectures that embody bus or sectional design while low status firms, catering to lay consumers, lean towards integral product architectures. The implication is that high status firms face significant barriers to open their innovation towards those customer segments that are most knowledgeable.

Implications and Conclusion

For firms involved, these combinations suggest certain strategic modalities. As the inroads of semiconductor technology into the photographic sector have rendered it products increasingly modular, their decision whether to "make or buy" will increasingly require them to accumulate social capital to implement alliances with firms that will embellish their status, assuming that status is a signal of quality for which firms receive premia. That social capital enables high status firms to guard their integrity (compare Podolny, 2005) lest their status will leak. Likewise, as Nickerson and Silverman (2003) indicates, firms endure higher transaction costs (or their delivery of output is costlier) when insourcing activities such as trucking , they face the dilemma of low versus high status as conveyed by whether firms operate as owner operators rather than as employees of large trucking chains.

We would, therefore, expect the photographic equipment manufacturers to partner with component (e.g. lens, flash, bag, CCD) suppliers who enjoy the status to match their OEM and ODM. Firms might enhance their status when they partner with high status suppliers, as illustrated by Panasonic and Zeiss Ikon. Interestingly, large spreads are observed among component prices, depending on the branding that is attached to the component.

At this stage, we are not yet ready to provide conclusive evidence for product design architecture, firm status, and the exchange relationships that emerge among alliances of firms which contract to design and manufacture photographic equipment. More data collection and analysis is to be completed. The arguments so far suggest, however, interesting ideas for pushing the insights regarding strategic alliances in sectors where insourcing and outsourcing is rampant and new firms of organization, whether virtual or otherwise are becoming prominent (e.g., Li, 2007, Sako, 2006). Our field study of photography shows ample evidence about insourcing becoming the dominant form of organizing—both for the design of components and architecture as well as their manufacturing, In fact insourcing and outsourcing appear to be even more common in the photographic sector than in sectors such as vehicle manufacturing and computing or telecommunication equipment. Yet, the knowledge to date remains incomplete regarding the governance of interfirm relationships and the sort of product architecture that can be mapped onto those exchange relationships.

Sako (2003) showed that among vehicle (MV) manufacturers in Japan (Toyota, Nissan and Honda) major variations exist around the coordination and knowledge transfer between these firms and their outsourcing partners. Toyota appears to behave more aggressively in the transfer of tacit knowledge onto their partners thus assuring a greater seamlessness between the components that make up its architecture. In her comparative case study, she finds that Nissan and Honda appear to behave more modestly when it involves the sharing of proprietary practices as distinct from "teaching" or representation of what often looms to be tacit knowledge such as the Toyota production system and its quality management. One would also expect the status of these firms and their suppliers to produce differences in firm performance and to reveal heterogeneity in product architecture. The management of exchange relationships within MVs has not reached the institutionalized similarity among the firms, thus inviting questions regarding competitive advantages and speed of innovation. The photographic sector might provide still another stage in which patterns of inter-firm interaction, in relation to product design inform us about the intricate relationships between product architecture, and the status among the insourcing and outsourcing firms.

The following propositions derive from the arguments.

1. As sectors witness a paradigm shift, the status legacy of their incumbents carries forward after the disruptive technology has replaced the established technology
2. Status constitute one of the major complementary assets that incumbent firms leverage in their strategic efforts as their sector transitions into a new technology and market
3. High status firms, compared to their low status peers enjoy a bargaining advantage when partnering with firms possessing complementary assdets
4. An incongruence exists among sectional versus integral product-market focus derived from customer sophistication and producer status.

5. High status firms produce modular equipment whose architecture suggests an integral configuration.

6. High status firms form close and embedded alliances with high status partners; low status firms form arms-length relationships with their suppliers

7. High status firms engage in "evolutionary capability" (capability for capability building—Sako, 2004) towards their insourcing partners, while low status firms resort to a more basic "maintenance capability" (ability to maintain performance consistency).

Name (removed in final version)	Position	Company (removed in final version)	Position	Firm Role	Industry	Location	Cumulative Interview Length (hours)
John Boydson		MegaVision	Engineer	R&D	Commercial and Medical Imaging	US	2.5
Phil Kern	Program Manager	Intergraph	Engineer	R&D, Manufacturing, Marketing to Businesses	Aerial Imaging	US	1.0
Gadi Ben-Mark	VP and General Manager	Intergraph	Manager	R&D, Manufacturing, Marketing to Businesses	Aerial Imaging	US	0.75
Dr. Alberto Goldszal		HUP	Scientist, Procurement Manager	Wholesale User	Medical Imaging	US	1.0
Herbert Keppler	Vice President	Popular Photography	Journalist	Publisher	Commercial Imaging	US/Japan	2.5
Christian Paulsen	Chief Executive Officer	Hasselbald	Manager	R&D, Manufacturing, Marketing to Professional Users	Commercial Imaging	Europe	2.75

Per Nordlund	Optical engineer	Hasselbald	Engineer	R&D, Manufacturing, Marketing to Professional Users	Commercial Imaging	Europe	0.5
[missing name]	Head of US operations	Tamron	Manager	R&D, Manufacturing, Marketing to Professional Users and Consumers	Commercial Imaging	US/Japan	1.0
Michihito Yamaki	Chief Executive Officer	Sigma	Manager	R&D, Manufacturing, Marketing to Professional Users and Consumers	Commercial Imaging	Japan	0.5
Angelique X. Irvin	Chief Executive Officer	Coviant	Manager	R&D, Manufacturing, Marketing to Governments	Military Imaging	US	1.0
Fabio Offredi	Director of Product Strategy and Planning	Philips Consumer Electronics	Manager	R&D	Consumer Electronics	Europe/Asia	2.5

Table 1**: List of Informants**

Target Consumers / Firm Status	Lay	Expert
Low	Undesirable position	Towards sectional design
High	Towards sectional integral	Undesirable position

Table 2**: Firm Status and Consumer Sophistication Matrix**

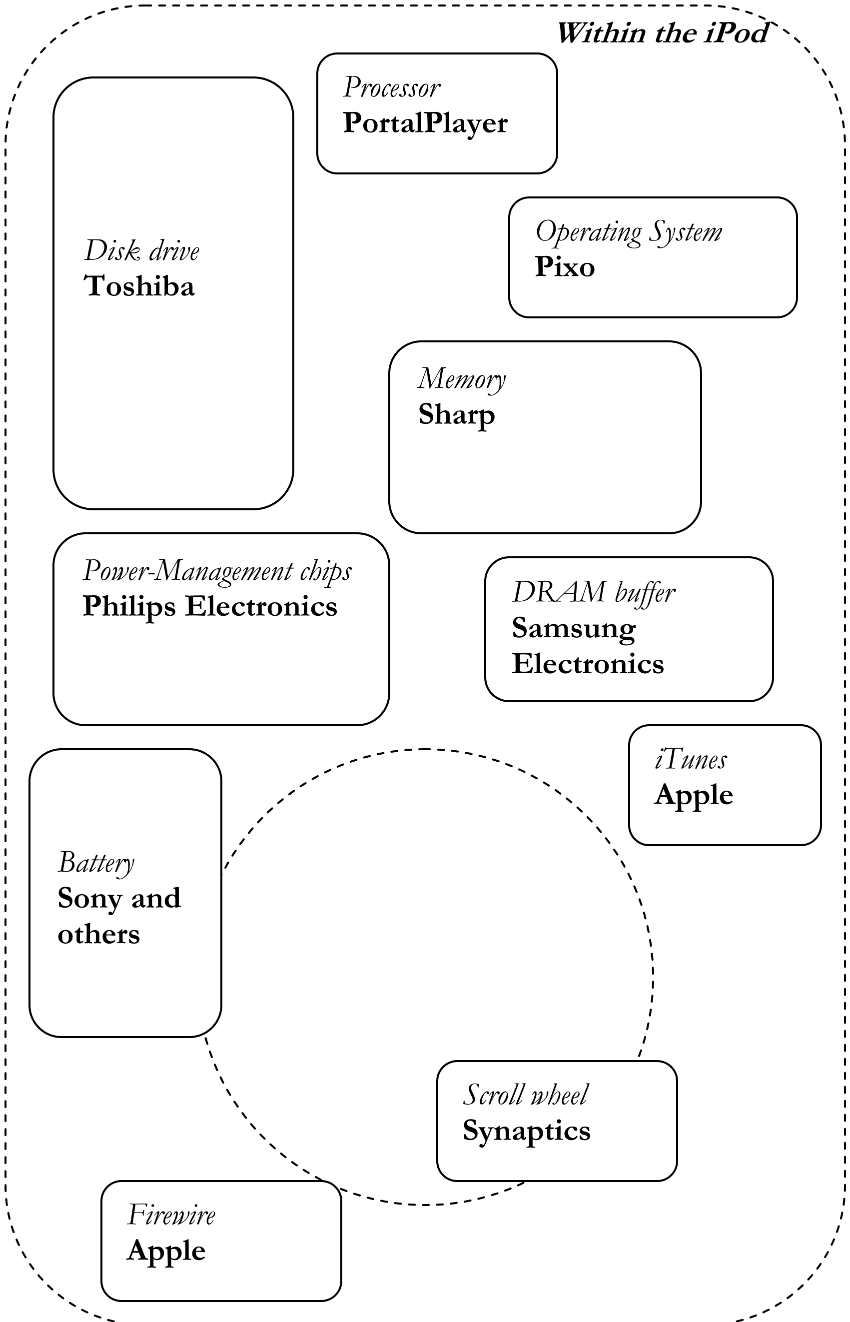
Within the iPod
Processor
PortalPlayer
Disk drive
Toshiba
Operating System
Pixo
Memory
Sharp
Power-Management chips
Philips Electronics
DRAM buffer
Samsung Electronics
iTunes
Apple
Battery
Sony and others
Scroll wheel
Synaptics
Firewire
Apple

Figure XXX: iPod Architectural Design Scheme

American Sociological Association. (2001). Informed Consent Process. In *Ethics code of the American Sociological Association (Section 12.02)*: www.asanet.org/members/ecostand2.html#12.

Baldwin, C. Y., & Clark, K. (2005). Designs and Design Architecture: The Missing Link between 'Knowledge' and the 'Economy'. *Working Paper, Harvard Business School.*

Bazeley, P., & Richards, L. (2000). *The NVivo Qualitative Project Book*. London: Sage Publications.

Burgess, R. W. (Ed.). (1995). *Computing and Qualitative Analysis*. London: JAI Press.

Day, J. H. (2005, January 20, 2005). Inside iPod. *Electronic Design*.

della Cava, M. R. (2005, Feb. 1, 2005). In iPod America, legions in tune; Apple's hip music player inspires fanatical devotion. *USA Today*.

Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine De Gruyter.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth Generation Evaluation*. Newbury Park, CA: Sage.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly, 35*(1), 9-30.

Jin-Seo, C. (2006, Dec. 18, 2006). Jack Welch's iPod Praise Irks Netizens *Korea Times*.

Levine, S. S. (2001). *Altruism in Cyberspace? The Voluntary Sharing of Goods On-line.* Paper presented at the Academy of Management Annual Meeting, Washington, DC.

Levy, S. (2006). *The Perfect Thing: How the iPod Shuffles Commerce, Culture, and Coolness*: Simon & Schuster.

Lexmark International, Inc. v. Static Control Components, Inc. (United States Court of Appeals for the Sixth Circuit 2004).

Li, W (2006) Global Sourcing in Innovation. Working paper, Los Angeles: UCLA School of Business.

Maxwell, J. A. (1996). *Qualitative research design*. Thousand Oaks, California: Sage Publications.

Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: a sourcebook of new methods*. Beverly Hills, California: Sage Publications.

Nickerson, J.A and Silverman, B.S. (2003) "Why Aren't All Truck Drivers Owner-Operators? Asset Ownership and the Employment Relation in Interstate For-hire Trucking," *Journal of Economics and Management Strategy*, 12(1), 2003, pp. 91-118

Podolny, J. (2005). *Status Signals: A Sociological Study of Market Competition*. Princeton, New Jersey: Princeton University Press.

Podolny, J. M. (1993). A status-based model of market competition. *American Journal of Sociology, 98*, 829-872.

Pogue, D. (2001, Oct. 25, 2001). Apple's Musical Rendition: A Jukebox Fed by the Mac. *The New York Times,* p. 1.

Sako, M (2004) Supplier development at Honda, Nissan and Toyota: comparative case studies of organizational capability enhancement, *Industrial and Corporate Change*, 13 (2), 281-308.

Sako, M (2005). Outsourcing and Offsourcing: key trends and issues, Background paper for Emerging Markets Forum, Said Business School, Oxford University.

Silverberg, B. (2005, Mar. 3, 2005). The ABCs of Tech Success; How can your business win in the world's fastest-changing industry? A surprisingly simple time-tested exercise can help you figure it out. *BusinessWeek Online*.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. Newbury Park, California: Sage Publications.

Tam, P.-W. (2001, Oct. 24, 2001). Apple Plans Digital Music Player, Moving Beyond Computer Buyers. *The Wall Street Journal*.
Tripsas, M., & Gavetti, G. (2000). Capabilities, Cognition, and Inertia: Evidence from Digital Imaging. *Strategic Management Journal, 21*, 1147-1161.
Ulrich, K. (1995). The Role of Product Architecture in the Manufacturing Firm. *Research Policy, 24*, 419-440.
von Hippel, E. (1986). Lead Users: A Source of Novel Product Concepts. *Management Science, 32*(7), 791-805.
von Hippel, E. (2005). *Democratizing Innovation*. Cambridge, Massachusetts: MIT Press.
von Hippel, E., & von Krogh, G. (2003). Open source software and the private-collective innovation model: Issues for organization science. *Organization Science, 14*(2), 209-223.
Walker, R. (2003, Nov. 30, 2003). The Guts of a New Machine. *The New York Times Magazine,* pp. 78-84.
Weiss, R. S. (1994). *Learning from Strangers: The Art and Method of Qualitative Interview Studies*. New York: The Free Press.
Wikipedia. (2006). Razor Blade Business Model. Retrieved December, 2006, from http://en.wikipedia.org/wiki/Razor_and_blades_business_model
Wingfield, N. (2006, Dec. 6, 2006). When iPods Die *The Wall Street Journal.*
Yoffie, D. B., & Slind, M. (2006). *Apple Computer, 2006*. Cambridge, MA: Harvard Business School Press.