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TECHNOLOGICAL EVOLUTION AND THE 'CONSTRUCTION' OF DOMINANT DESIGNS IN THE IMAGING INDUSTRY

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ABSTRACT

All industries occasionally experience technological shocks or 'discontinuities.' These discontinuities may be competence-enhancing or competence-destroying. Competence-destroying discontinuities threaten to render existing capabilities obsolete and lead to 'eras of ferment' in which the new technology competes with the old one. At the same time, several designs within the new technology struggle for dominance. Managers faced with such a situation need to make several important decisions, perhaps the most important of which involve the selection of technologies to adopt or develop. Existing competencies and market positions provide strong constraints on the objective of meeting evolving customer expectations. The decisions are expensive and fraught with risks. Naturally, a better understanding of how technologies tend to evolve and why particular designs become dominant, while others, equally plausible ones, do not, would help managers make more informed decisions and avoid costly mistakes or even the prospect of lock-out.

This primary aim of this dissertation was the development of a better theoretical understanding of this complex process. Relying primarily on archival data, narratives were constructed around four cases of radical technology shifts in the photographic industry. When woven with existing theoretical insights, these narratives yielded a new perspective on technology dominance. It proposes that contrary to the popular perception that customers eventually adopt technologies that meet their needs 'better,' the success or failure of a new technology is dependent on the extent to which its proponent can build it into the emerging institutional context. This involves opening the design up to embody the interests of key stakeholders as well as structuring the field. At the same time associations and linkages are created between the technology and existing structures. "Enrolling" institutions in this manner stabilizes the nascent technology, reducing its disruptiveness and creating positive externalities around it. How long the design stays dominant depends upon its position in the industry architecture (Christensen, 1997). If it is positioned as an obligatory passage point (Latour, 1987), it is likely to stay dominant for much longer than if it is simply the foremost technological solution to the central problem.

RESUME

Toutes les industries passent occasionnellement par des chocs technologiques ou des "discontinuités". Ces discontinuités peuvent soit valoriser, soit détruire les compétences. Les discontinuités qui détruisent les compétences menacent de rendre les capacités existantes obsolètes et de mener à des "ères de fermentation" au cours desquelles la nouvelle technologie est en concurrence avec l'ancienne. En même temps, plusieurs designs dans la même techologie luttent pour la domination. Les gestionnaires qui ont affaire à une telle situation doivent prendre de nombreuses décisions importantes, parmi lesquelles la plus importante est probablement la sélection des technologies à adopter ou à développer. Aussi, les compétences existantes et les positions sur le marché constraignent-elles fortement l'objectif de faire face aux attentes changeantes des clients. Les décisions sont couteuses et très risquées. Donc, une meilleure compréhension du "comment" de l'évolution des technologies et du "pourquoi" de la domination de certains designs sur d'autres pourtant tout aussi plausibles, aiderait les gestionnaires à prendre des déscisions mieux informées et éviter de couteuses erreurs, voire la perspective de la mise hors-jeu de l'industrie.

Le but principal de cette dissertation est de de développer une meilleure compréhension théorique de ce processus complexe. Nous basant sur des données d'archives, nous avons élaboré des narratives portant sur quatre cas de changement radical de la technologie dans l'industrie photographique. Une fois reliées aux approches théoriques, ces narratives ont généré une perspective nouvelle sur la domination technologique. Cette proposition est que, contrairement à la perception populaire que les clients éventuellement adoptent une technologie qui sert "mieux" leurs besoins, le succès ou l'échec d'une nouvelle technologie est en fait fonction de la capacité de ses promoteurs à l'insérer dans le contexte institutionnel émergent. Cette capacité implique d'ouvrir le design pour y incorporer les interêts des principales parties prenantes ainsi que de structurer le champ. En même temps, les associations et les liens se créent entre la technologie et les structures existantes. Les institutions qui "enrôlent" de cette façon stabilisent la technologie naissante et réduisent son caractère disruptif, créant ainsi des externalités positives autour de celle-ci. La durée de la permanence du design est fonction de sa position dans l'architecture de l'industrie (Christensen, 1997). Si elle est positionnée comme un point de passage obligé (Latour, 1987), il est probable qu'elle demeure dominante plus longtemps que si elle est simplement la solution essentiellement technologique au probléme central.

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When I arrived in Canada to do a Ph.D almost six years ago, I had no idea what I was getting into. A Ph.D in management, as far as I was concerned, was just an advanced M.B.A. I could not have been more wrong! In stark contrast to an M.B.A degree, a Ph.D is an incredible intellectual journey that completely transforms one's perspective on life (for better or worse). It opens up doors to new worlds and leads one to places where he/she could never have imagined going before. Naturally, there is a catch: you have to produce a dissertation at the end of this journey. This minor detail can throw a wet blanket over the whole experience. Fortunately, there are people on the way who make this task easier through their unconditional support. To all such people who so graciously helped me on my way, I am greatly indebted.

First and foremost, I would like to thank my thesis committee for standing by me when I was floundering. Over the years, my research interests changed seasonally, and my committee waited patiently and held my hand until I rediscovered equilibrium, only to lose it again. Jan Jorgensen, especially, has seen it all happen one too many times. All I can say is that his reservoir of patience is enormous. Even to this day, I am surprised by his commitment to his students and the lengths to which he will go to help them. He listened, counseled and provided me with much needed confidence, when I most needed it. To him, I will forever be grateful.

During my first year, I occasionally saw a bearded person sitting in various seminars. His hair was long, and he always wore denim. I often wondered who he was, and why was he always laughing? As it turned out, his name was Nelson Phillips and he was incapable of being unhappy. It was difficult not to gravitate towards him. Nelson ended up supervising my dissertation, and becoming a very close friend. His cheerfulness, I found out, was contagious. Whenever I had that sinking feeling which every Ph.D. student invariably experiences when things are not working out, or when you find out that for the past six months you have essentially wasted your time researching an idea in which nobody is interested or which has already been done and disposed of, I turned to him. Inevitably, I returned with my spirits once again high. For all those times, and much more, I would like to extend my sincere gratitude.

Deborah Dougherty was my co-chair, until she moved to Rutgers University. Most of what I know about doing qualitative research, management of innovation, and simply writing well, I have learned from her. Deborah is a one of the most sincere people I have met in my life, and her capacity to involve her students in her research and thereby provide them with invaluable experience (not to mention the dollars) is enormous. Her commitment to her students is phenomenal. All her students know that if they turn in a 30 page paper for her to read, it will come back with 20 pages of comments! And that remains true even after you graduate! So we have to keep thanking Deborah!

Finally, I wish to thank the external member of my committee, who was by no means 'external' to the process of this dissertation, or to my intellectual journey. Taieb Hafsi helped me put things in their proper perspective and discern order in chaos. Always, always full of encouragement, he gave me the confidence necessary for doing research. His advice was (and is) always sound and pragmatic and I am extremely grateful for it.

Apart from my committee, several other people provided unconditional support that helped me get through this process. Foremost among them is my friend and colleague Stelios Zyglidopoulos, who was always there when I needed him. Then there was the 'coffee-gang,' with whom I spent countless hours arguing whether technology can be *socially constructed* or whether digital cameras will ever replace traditional cameras! Tripat Gill, Abdullah Dasci and Muhammad Oskoorouchi have helped me hone my arguments over countless coffees. Vanessa Reid and Sarwat Viquar were instrumental in the editing of this thesis and I thank them for it. Finally, Emanuel Raufflet was kind enough to edit the French translation of the abstract.

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Above all, however, I wish to thank my wife and my father without whose support I could not have even dreamed of finishing or carrying on. While my father managed things back home in Pakistan, always ironing out all turbulence, my wife provided constant encouragement and helped maintain my sanity throughout the Ph.D. process. In the last year, Zehra arrived to change our lives forever. Zehra is one of the most cooperative and cheerful babies ever, and I wish to thank her for being so. Finally, I would like to dedicate this thesis to the memory of my mother, Zahida Munir.

Needless to say, while all those mentioned above have contributed to this dissertation, I alone am responsible for its contents, particularly errors and omissions.

INTRODUCTION

The importance of innovation cannot be overemphasized in today's world. It is the central determinant of long-run success or failure of organizations (Jelinek and Schoonhoven, 1990; Utterback, 1994). It allows organizations to enter new markets, revitalize existing product lines and keep up with rapid technological developments in the environment. In order to be successful, however, new products need to integrate customer needs with technological capability (Burns and Stalker, 1961; Clark and Fujimoto, 1991; Dougherty, 1996). The product's function, structure and 'semantics' must fit the customer's objectives, values, production system, lifestyle, use-pattern, and self-identity (Clark and Fujimoto, 1991: 30). Thus understanding customer needs is essential to product success.

However, in several situations, more than a single technology can meet customer needs. For example, Cusumano, Mylonadis and Rosenbloom (1992) have argued that in the videocassette recorder industry there were two technologies, which could meet customer objectives and expectations equally well. In fact, Sony's Betamax technology was technically superior to the VHS technology, which eventually came to dominate the market. Similarly, today Netscape Navigator can provide all the benefits to the customer that Microsoft's Internet Explorer can. Still, sales for the latter are soaring while Netscape's market share is declining fast. In such cases, what makes matters worse for the losing firms is that winning technologies carry increasing returns to adoption (Arthur, 1989). Once a technology is adopted, it becomes increasingly attractive to new users because of learning by using, network externalities, scale economies in production, informational increasing returns, and technological interrelatedness (see Arthur, 1989 for detailed descriptions of these factors). The organization that cannot develop a market for its design right in the beginning faces a losing battle. Similarly, some organizations are able to come out with highly advanced technologies but are unable to profit from their innovations. For example, firms such as Apple, Xerox and EMI were unable to sustain the competitive advantage that their technological innovation provided them with.

Thus, the goal facing innovating firms is not limited to integrating customer needs with technological capability, but includes generating acceptance for their particular technology in the market, and maintaining their grip on successful designs. In fields such as software development, electronics or telecommunications, technological changes in the environment continue to outpace the internal product development cycles of most organizations. Technological discontinuities (Anderson and Tushman, 1990) are frequent and determining undefined customer needs exceedingly difficult (Schilling, 1998). It is imperative for organizations not only to increase the pace of innovation but also to generate acceptance for their designs in the market while keeping the design attached to themselves. Sony's Betamax design did not fail because it did not meet customer needs but because Sony was unable to build a market for its product. Microsoft's Windows, possibly the most successful product of the decade, owes its enormous success to Microsoft's ability to bring about widespread 'selection' of its design.

Organizations which desire to obtain a sustainable competitive advantage based on their technology must develop a sound understanding of how designs get selected in the market (Tushman, Anderson and O'Reilly, 1997). If a design is unable to get selected in the market, it usually dies away regardless of whether it meets customer expectations or not. For example, Nexgen, a CPU manufacturer, was locked out of the market when it discovered that it could not make CPUs identical to Intel's dominant standard because of patents. Nexgen chose to market its own design, which possessed a slight speed advantage over the Intel architecture, but increasing returns had already started accumulating for Intel and Nexgen was selected out of the market (Schilling, 1998: 267).

The problem that I address in this study is as follows: In situations where more than one design can meet customer expectations, or in situations where customer needs are still undefined or difficult to predict, how are successful designs selected in the market, and how may firms influence this process? Recent research has shown that such situations regularly arise with the introduction of radically new technologies (Nord and Tucker, 1987). In case of radically new technologies, consumer expectations are as much shaped by new designs as the designs are shaped by firms' understanding of consumer needs (Cusumano, Mylonadis and Rosenbloom, 1992; Christensen 1997). Immediately after a radical discontinuity, consumer expectations are largely unspecified, ambiguous and constructed within the existing technological paradigm (Christensen and Bower, 1996; Christensen, 1997; Schilling, 1998).

The photographic industry presents an ideal situation to study such situations and thus develop further insights into how designs get 'selected' for several reasons. First, the industry has experienced several radical discontinuities in the past and thus offers the necessary diversity both temporally and technologically. Second, these discontinuities have led to varied outcomes, ranging from unprecedented heights of success to complete failure and elimination, making the study all the more interesting and insightful. Third, the industry is centered on a popular activity which is arguably shaped both socially and technologically[1]. Finally, and perhaps most interestingly, this industry offers an excellent opportunity to observe a technology-in-making. After years of incremental changes, this highly competitive industry is suddenly faced with a radical technological discontinuity in the shape of digital imaging technology. Incumbent players are being threatened by newcomers with strong capabilities in digital imaging technology thus threatening to render obsolete traditional chemical-based capabilities developed by incumbents over several decades. It is possible to witness first hand, the struggle between various players as they vie to make their particular capabilities key to the emerging dominant design, and the strategies that they employ to achieve that goal[2].

I chose four cases of radical technological discontinuity within the photographic field: Roll-film technology (introduced by Kodak), Instant photography (Polaroid), Disc technology (Kodak) and Digital Imaging (primarily Sony). It is important to remember that this study studies technological change within the confines of an institutional field (defined in chapter 2), rather than an 'industry' thus expanding the scope of the data to be collected and the factors that need to be considered when evaluating technology evolution. Among the cases, the Roll-film camera was a historic success and has remained dominant for about 100 years. Instant photographic technology, introduced by

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[1] Tushman and Rosenkopf (1994) among many others (e.g., DiMaggio and Powell, 1983) have emphasized the need for studying situations where social forces are expected to interact significantly with technological ones.

[2] Latour (1991) suggests that the best time to study a technology is during its construction. At that time, the future of the technology is wide open. Decisions are still being made regarding the material to use, the customer needs to satisfy, the markets to explore, the standards to incorporate or adapt to and so on. Once, however, the product or design is a success, all these decisions are considered vindicated by the market as well as by researchers, mostly leading to functional explanations of technological success. On the other hand, while the black box of technology is still open, and the fate of the design undecided, each possibility regarding materials to be used, markets to focus on, competing customer needs to satisfy, and standards to adapt to, seems equally plausible, leading to a more objective point of view.

Polaroid shot to instant stardom, but then experienced a gradual fall. Disc cameras were expected to be the future of photography, and broke all sales records in the first year, but then suffered a fall that was equally dramatic. Finally, where digital-imaging technology is concerned, the jury is still out.

The research was driven by five questions that emerged out of an examination of available insights and research on technological dominance (described in chapter 1). My methodology was case-based involving in-depth interviews with several key executives in the industry, participation in industry conferences and activities, archival research (mostly in New York Public Library) spanning the last hundred years, and utilization of secondary sources such as trade magazines, journals and market research[3]. The findings were interesting and significant. Not only did they address the research questions that I started with, but also led to a new, more interpretive and comprehensive explanation of technological evolution.

The findings of this thesis stand to contribute significantly to theoretical and conceptual development in the areas of competitive strategy, technology evolution, and to managerial practice. At the outset, they indicate that rather than being inherent, superiority of a technology is in fact an acquired trait. From the time that an idea or technology is introduced to the point when it becomes dominant, it undergoes several transformations, in its architecture, composition, functionality, external linkages, and social meaning. Through these transformations, the design comes to embody the interests of several actors, incumbents and/or new entrants. This process of embodiment of interests starts at the product design stage and continues as the technology becomes part of stakeholders' future plans. Through its association with emerging and existing social (and technological) institutions, the meaning attributed to the design transforms. At the same time, the design transforms the meaning of the activity that it facilitates[4]. This interactive process, in which technologies (not only the focal one, but several others which come to be linked or associated with it) interact with the social process leads to the emergence of a new institutional field, which is not centered around only technology,

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[3] The methodology is described in greater detail in chapter 2.

[4] Technologies act as important structuring devices in social life and enjoy a recursive relationship with social action (Giddens, 1984).

only its social meaning or only the 'issues' that it raises, but around the ongoing interaction of all three. Finally, a design is nothing on its own. Firms or managerial agency mediate the relationship between technology and customers, constructing meaning around it. Accordingly, dominant designs do not 'emerge,' as most research suggest, but are 'constructed' through a process which involves 'framing' the technology and linking/ associating it with social and technological institutions.

The perspective developed here conflicts with the 'under-socialized,' functionalist views on technology as well as with the 'over-socialized', social-constructivist perspectives. Technological evolution is neither driven by technological/ functional considerations alone, nor by social ones only. It is rather, the interaction between the two, mediated by the institutional framework of the context that shapes the evolutionary process. The findings of this thesis also run counter to several notions that seem deeply entrenched in the photographic industry. For instance, the faith in the inherent superiority of particular technologies that most managers display is not only misplaced but also outright dangerous from a strategic point of view[5]. Kodak's roll-film cameras did not succeed because 'that's what the people wanted' (the technology had been around for some time and when Eastman first marketed it, they failed miserably). The Disc camera, which arrived to unprecedented accolades, did not fail because it was inherently an 'inferior' product. Polaroid cameras did not fail because the quality was below par or because of the arrival of one-hour film processing. And finally, Sony's digital camera, the MAVICA, did not succeed because it was 'simple.' Hopefully, managers in the photographic industry, as well as those outside it, will find my findings insightful, or at the very least, thought provoking.

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[5] Most managers that I interviewed were inclined to judging technologies by using the existing evaluation criteria.

CHAPTER 1: MOTIVATION FOR RESEARCH

Technological[6] change is one of the most crucial challenges facing organizations today (Jelinek and Schoonhoven, 1990; Utterback, 1994; D'Aveni, 1994; Greenwood and Hinings, 1996). The telecommunications revolution, the evolution of the Internet, advances in electronics and the subsequent convergence of industries are dramatically altering contextual forces. Consequently, coping with their results has become a key determinant to competitive advantage and organizational survival (D'Aveni, 1994). In the midst of all these changes, managers charged with the responsibility of introducing a new technology in the market; betting on one of several competing technology development projects; deciding when to enter the fray after a technological discontinuity; or, determining which of several technologies to base future products on, need some understanding of why certain technologies become successful while others, arguably superior, do not (Tushman et al, 1997). We can expect managers who possess a better knowledge of the dynamics of technological evolution and how the evolutionary process can be influenced to make more informed decisions with a higher probability of success.

This research study seeks to provide a general theory of technology evolution by addressing two kinds of questions: why and how do particular technologies come to dominate[7] industries, while other, equally plausible candidates cannot/do not (Arthur, 1989; Tushman et al, 1997). Addressing the 'why' involves developing an understanding of 'inherent' vs. 'acquired' superiority of technology. In other words, are the technologies that come to eventually dominate in some way different from those that fail, or are there other, non-technological factors involved? Conversely, addressing the 'how,' entails explaining the process through which a technology is transformed from its introduction to its dominance.

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[6] Technology is defined here as those tools, knowledge and methods that allow agents in a field to deliver on their claims. It is a complex system of engineering and scientific knowledge, techniques, arrangements of equipment, and networks of operating subsystems (Dougherty, Borrelli, Munir and O 'Sullivan, 1998).

[7] A technological design is usually called dominant when more than 50% of products in a single class come to be based on it (Tushman and Anderson, 1986). It represents a combination of several technological standards and its dominance may be based on its configuration, the system architecture, or the process by which these products or services are provided.

Needless to say, considerable research has been done on this question. Researchers from a range of perspectives have examined this problem and come up with valuable insights that have significantly improved our understanding of this issue. At the same time, it is possible to identify some gaps in this literature. In this chapter, I review these research streams and identify both the gaps which remain and those which need to be filled. These gaps are presented in the form of research questions that drive the empirical part of this study.

LITERATURE REVIEW

Since this dissertation is primarily motivated by organizational and managerial concerns, the / logical place to begin searching for answers to the questions described above is in the core research stream of technology evolution within the discourse of management theory. Starting with Abernathy and Utterback's (1978) seminal article, research on technology evolution within management theory has developed steadily and impressively over the years (Tushman and Anderson, 1986; Utterback, 1994; Tushman and Rosenkopf, 1994; Christensen and Bower, 1996). In recent years, useful insights developed by researchers in the areas of 'path dependency' (Arthur, 1989; Barnett, 1990), as well as social construction of technology (SCOT) (Hughes, 1983; Bijker and Law, 1992) have gradually been incorporated into this expanding body (Garud and Rappa, 1994). Finally, though to a lesser degree, research informed by the structuration perspective (Giddens, 1984) has enriched existing knowledge on technology evolution by emphasizing the recursive relationship between technologies and action (Garud and Kumaraswamy, 1993; Garud and Rappa, 1994). Moreover, insights from institutional theory have also been leveraged in this growing literature on technological change (Van de Ven and Garud, 1995). Drawing upon all these perspectives, I discuss insights that are currently available in the literature regarding technology evolution.

Technology Cycles

While scholars within management may differ in their theoretical approaches to understanding technological evolution, most agree that industry evolution follows technological cycles (Anderson and Tushman, 1990). Technology cycles are initiated by 'technological discontinuities' that trigger periods of technological and competitive ferment (Figure 1.1). Discontinuities are simply technological innovations, which may either improve performance product substantially (in which case, they may be known as sustaining innovations) or completely redefine the performance trajectory utilizing a completely new technology (in which case they are called disruptive innovations)[8]. Sustaining innovations are usually 'competence-enhancing' (Tushman and Anderson, 1986). These innovations occur on the existing technological trajectory, and while the innovator may attain a lead over competitors by virtue of first-mover advantage, the latter are usually able to catch up over time. On the other hand, 'comptence-destroying' innovations bring previously unused, or completely new technological knowledge to the industry, threatening to destroy prevailing incremental innovation patterns and render existing capabilities useless. Henderson and Clark (1990) have pointed out that slight changes in the product architecture can also prove difficult for competitors to imitate, and hence prove 'competence-destroying.' After such discontinuities, innovators struggle to develop applications based entirely, or partially, on the new technology. These applications generally employ widely different architectures, configurations, features and standards (Anderson and Tushman, 1997). As a result, various trajectories are opened up along which technological evolution in the industry can take place. These include innovations based on existing technology, various designs based on the new technology,

[8] Sustaining and disruptive innovations is the classification scheme employed by Christensen (1997). Other researchers, such as Tushman et al (1986; 1990; 1998) distinguish discontinuities on the basis of their 'competence-destroying' or 'competence-enhancing' effects. I prefer Christensen's scheme, since it avoids defining discontinuities based on their effects, or damage caused. Henceforth, whenever I refer to discontinuities, I mean disruptive innovations, which threaten to destroy existing capabilities (Roll film, Instant photography and digital imaging all constitute innovations that destroyed, or threatened to destroy existing capabilities; Some could argue that disc technology was a competence-enhancing, or sustaining innovation, since it sought to improve product performance, but its proprietary nature and advanced technology posed a major threat to competitors, for which reasons I have treated it as a competence-destroying discontinuity).

and quite often, hybrid technologies which promise to marry the strengths of the entrenched technology to the promised benefits of the new technology[9].

Figure 1.1 About Here

These turbulent periods of innovation and uncertainty end with the emergence of an industry standard or dominant design (Abernathy and Utterback, 1978; Anderson and Tushman, 1990; Utterback, 1994). For example, in early radio transmission, continuous wave transmission was a technological discontinuity that threatened to replace spark-gap transmission. Continuous-wave transmission initiated competition not only between continuous wave transmission and spark-gap transmission, but also between three variants of continuous wave transmission: alternating wave, arc, and vacuum tube transmission. This period of technological ferment led to vacuum tube transmission becoming the dominant design in radio transmission (Rosenkopf and Tushman 1994). The emergence of a dominant design ushers in a period of incremental as well as architectural technological change, which at some point, is broken by the next substitute product. An example of this is the evolution of typewriters wherein electronic typewriters replaced electric typewriters, which had previously replaced mechanical typewriters. This technological discontinuity then triggers the next wave of technological variation, selection, and retention (see Tushman et al, 1997).

Dominant Designs

Since Abernathy and Utterback's (1978) seminal work, in which they introduced the concept of dominant designs, technology has been understood to evolve in any industry in a series of variation, selection and retention cycles in each product class,

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[9] Discontinuities are shown as a single point in time on most diagrams of technology cycles. This represents the introduction of the new technology in the focal industry for the first time. Thus, Sony's demonstration of how digital technology could be used for imaging in amateur-cameras may be called a discontinuity, or a disruptive innovation. Since we have the benefit of hindsight in all cases presented in this study, I follow this tradition. Otherwise, it may be more accurate to call such technology introductions as 'potentially disruptive innovations' since it is only later that it is decided whether the technology is going to be disruptive or not. For the purposes of this study, pin pointing the exact time when a discontinuity occurred is irrelevant, although this could be an interesting question in its own right with important implications for research.

which then results in dominant designs. A dominant design in any product class is the one that "wins the allegiance of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following" (Utterback, 1994: 24). It usually takes the form of a new product synthesized from individual technological innovations introduced independently in prior product variants. For example, the Underwood Model 5 typewriter emerged as a dominant design, bringing together its single QWERTY keyboard, visible type, tab feature, shift-key capitalization, and carriage cylinder, among other things. This combination of features defined how the "typewriter was supposed to look and operate in the minds of both typists and other typewriter producers" (Utterback, 1994: 25). Similarly, the IBM PC format, which emerged as a dominant design, offered little in terms of breakthrough technology (Teece, 1988) but it brought together familiar elements that had proven their value to users: a TV monitor, standard disk drive, QWERTY keyboard, the Intel 8088 chip, open architecture, and the MS DOS operating system. Together, these elements came to define the idea of the personal computer for at least 80 percent of the market.

The concept of dominant designs has been reified over time through several studies which form an impressive research stream. The primary research in this domain includes he process through which certain designs became dominant (Tushman and Rosenkopf, 1992; Utterback, 1994; Van de Ven and Garud, 1994); shifting industry structures (Abernathy and Clark, 1985); industry dynamics and technology cycles (Tushman and Anderson, 1986; Anderson and Tushman, 1990; Garud and Kumaraswamy, 1993). Other fields of research are: theinfluence of network externalities on the emergence of a single design (Arthur, 1988; Barnett, 1990); community-level dynamics (Wade, 1995; 1996); the difficulties of adapting to a new 'architectural' design (Henderson and Clark, 1990); entry/exit rates and organizational mortality (Baum, Kotha and Korn, 1995; Suarez and Utterback, 1995); the institutional basis of dominant designs (Van de Ven and Garud, 1994); their socio-cognitive dimension (Garud and Rappa, 1994); and, the various levels at which dominant designs emerge (Tushman and Murmann, 1998).

While the studies mentioned above differ over various aspects of dominant designs, a consensus seems to exist around the fundamental concept. After each technological discontinuity, a dominant design arises that embodies the requirements of many classes of users of a particular product, even though it may not meet the needs of a particular class to quite the same extent as would a customized design (Utterback, 1994). Nor is a dominant design necessarily the one that embodies the most extreme technical performance. In terms of the interplay of technical possibilities and market choices, dominant design is a so-called satisficer of many rather than an optimizer for a few.

A dominant design is understood to drastically reduce the number of performance requirements to be met by a product by making many of those requirements implicit in the design itself. Thus, few today would ask if a car had an electric starter and electric windshield wipers, whether a typewriter could produce upper- and lower-case letters, or whether a personal computer had a built-in disk drive, though these were unique features in models that preceded the dominant design. Today, these features are implicit in designs; not only does the market expect these features, but producers find themselves compelled to emulate them. Because they are mainstreamed, they are no longer advertised as advantages of one or another manufacturer's product. They are subsumed within the popularly accepted design.

The technological discontinuities that lead to dominant designs are relatively rare, unpredictable advancements in technology which often destroy existing incremental innovation patterns and threaten to render existing capabilities useless. Consequently, the emergence of a dominant design in a product class means either adaptation or extinction for competitors. If a firm has all its resources committed to the existing technology and does not possess the absorptive capacity to develop the required capabilities in the new technology, it may find itself locked-out of the market (Schilling, 1998). Thus, when Eastman Kodak's roll-holder camera became the dominant design in the photographic industry, most other firms specializing in dry-plate cameras went out of business. On the other hand, when the VHS standard emerged as dominant in the VCR industry, firms engaged in the production of Betamax VCRs were able to adapt later on although at a significant cost. Often, however, even after competitors decide to adapt their designs to the dominant design, they are not able to manufacture products based on the new design with enough efficiency, and thus cannot sustain themselves for long. Studies at the population level have shown (Baum, Korn and Kotha, 1995) that several firms often disappear from the industry when a new design emerges.

THE EMERGENCE (OR CONSTRUCTION) OF DOMINANT DESIGNS AND RESEARCH QUESTIONS

In the era of ferment, knowing which technology to invest in, when to enter the fray, and how to raise the probability of success of one's technology are questions of tremendous importance for managers. A better understanding of the process through which designs emerge as successes or failures would surely lead managers as well as public policy-makers to make more educated and informed decisions about the resource allocation process as far as investment in new technologies is concerned. However, increasing evidence that the answers to such questions do not lie solely in the technological realm has complicated the situation. No longer is a purely technological or functional view of evolution considered sufficient by researchers (Tushman and Rosenkopf, 1994; Garud and Rappa, 1994). Nor is it considered adequate to draw the boundaries of our analysis around merely the technology or even the industry (Sampler, 1998). Utterback (1994) has suggested that the emergence of dominant designs is the result of the interplay between technical and market choices at any particular time. However, Utterback points out that the idea of a dominant design is conceptually broader than technical competition and progress. Factors other than technology come into play; chief among these are collateral assets (Teece 1988), industry regulation and government intervention (Baum, Korn and Kotha, 1995), strategic maneuvering by individual firms (Cusumano, Mylonadis and Rosenbloom, 1988), and communication between producers and users (Utterback, 1994).

Tushman et al (1997), however, go further than just strategic maneuvering and government intervention to argue that the emergence of dominant designs is a function neither of the invisible hand of the market, nor of natural selection, but of complex socio-political competitive processes. They maintain that except for the most simple, nonassembled products like cement[10], the closing on a dominant design is not technologically driven. Rather, dominant designs emerge out of competition between alternative technological trajectories initiated and pushed by competitors, alliance groups, and governmental regulators, each with their own political, social, and economic agendas. Thus, Tushman and Rosenkopf (1994) have suggested that technology theorists' chief concern should be uncovering the role of non-technological forces in technological evolution.

Moreover, several authors have pointed to the importance of clout in determining the success and failure of technologies. For instance McGrath, MacMillan and Tushman (1992) argue that the pace at which dominant design is implemented can be slowed or accelerated depending on the amount of power and influence the originator and its competitors have with key stakeholders such as distributors, customers, regulators and suppliers in the industry. The importance of the company's reputation behind the design cannot be overestimated. According to Teece (1988), one of the major reasons IBM's PC became a success despite its ordinary architecture and off-the-shelf parts, was because of the letters I, B, M, which were written on the machine:

> The name implied that the product would be marketed and serviced in the IBM tradition. It guaranteed that PC-DOS would become an industry standard, so that the software business would not be dependent solely on IBM because emulators were sure to enter. It guaranteed access to retail distribution outlets on competitive terms. The consequence was that IBM was able to take a product that represented at best a modest technological accomplishment and turn it into a fabulous commercial success. (Teece, 1988; 640).

However, despite the seemingly heavy influence of the company's reputation and entrenchment in the industry, there are as many cases of such firms' failure to generate

[10] I personally do not consider cement to be a good example of an industry without a dominant design, since there are particular mixes that are universally acknowledged to be the best alternatives in particular situations. Furniture, on the other hand, might be a better example.

market acceptance of their designs. The case of the photographic industry reinforces this point. Industry-giant Kodak's repeated failure to generate acceptance for various innovative products, for which there seemed to exist a need shows that industry clout is not enough to ensure selection of a dominant design. It is almost ironic that the Kodak enterprise, which invented and popularized the roll film in the first place, was unable to replace it with newer products such as cartridges or discs.

Tushman et al maintain that due to these 'socio-political' forces, "the winner of the design competition is seldom at the industry's performance frontier; typically, the industry pushes the state-of-the-art forward during the era of ferment, then standardizes on a design that is *behind* the leading edge of the technology" (Anderson and Tushman, 1997: 49). There are important implications to this observation. First, it implies that during eras of ferment, managers must focus on something other than technological superiority. Second, it implies that there does exist an identifiable 'leading edge of technology.' If, however, we take into account findings reported by Christensen (1997) where customers were found to have ambiguous expectations after a radical technological discontinuity, we are forced to ask if, in such an ambiguous situation, it is even *possible* to assess the superiority of a particular technology or design? After all, technology is the application of scientific principles to meet some social objective. The best technology would be the one which meets the objective (usually customer needs) in the best possible manner. When customer needs are not fully defined or are still changing, how can one technology be deemed superior to others? Moreover, managers are required to bet on one of the several competing technologies during this era. How are they supposed to judge which technology to allocate resources to? This leads us to our first research question:

Q1 a. Following a radical technological discontinuity, when customer needs and expectations are ambiguous at best, and when several technological designs are competing against each other, is it possible to assess the 'superiority' of a particular technological design?

Q1 b. During the era of ferment, is it possible to distinguish between designs that are more likely to become dominant and those less likely?

Selection of a Technology: Path Dependence

More recently, much work has been done in Industrial Organization on the question of why certain designs or technologies are adopted over others (Katz and Shapiro, 1985; Arthur, 1989; Barnett, 1990; Langlois and Robertson, 1992; Arthur, 1994). Arthur (1989; 1994) is perhaps the foremost proponent of this view, which attributes dominance of particular technologies to 'increasing returns' to adoption. According to Arthur,

> What makes competition between technologies interesting is that usually technologies become more attractive – more developed, more widespread, more useful – the more they are adopted. Thus competition between technologies usually becomes competition between bandwagons, and adoption markets display both a corresponding instability and a high degree of unpredictability (Arthur, 1989: 590).

Increasing returns to adoption accrue from several sources, among which five stand out:

i) **Learning by using.**

Often the more a technology is adopted, the more it is used and the more is learned about it; therefore, the more it is developed and improved.

ii) **Network externalities**

(Katz and Shapiro, 1985; Langlois and Robertson, 1992).

There are many products for which the utility that a user derives from the consumption of a good increases with the number of other agents consuming that good. There are several possible sources of these positive consumption externalities. For instance, the consumption externalities may be generated through a direct physical effect of the number of purchasers on the quality of the product such as in case of a telephone network. They could be a result of indirect effects as in the case of operating systems where a consumer buys hardware that he or she thinks will become the dominant system in future. Or, the consumption externalities could simply be due to the existence of a reliable after-sale service network.

iii) **Scale economies in production.**

This refers to where a technology is embodied in a product like the Polaroid technology, the cost of the product falls as increased number of units of it are produced.

iv) **Informational increasing returns.**

Often a technology that is adopted enjoys the advantage of being better known and better understood when compared to other alternatives.

v) **Technological interrelatedness.**

Often as a technology is increasingly adopted, a number of other sub-technologies and products become part of its infrastructure. For example, the gasoline technology has an immense infrastructure of refineries, filling stations, and auto parts that rely on the primary industry.

Path dependency theorists such as Arthur suggest that a technology becomes successful only if a bandwagon forms around it. Random events can generate more acceptance for an 'inferior' technology in the beginning. As increasing returns to adoption kick in, soon a once inferior technology becomes the best alternative. 'Low-level' events, stemming from the inherent graininess of the market, can lead to the adoption of a technology which may not be superior at the outset, according to Arthur. Thus, he maintains, "if a technology gets ahead by good fortune, it gains an advantage" (1989: 591).

If, however, positive externalities exist in an industry, the adoption of new technologies does not remain random (Barnett, 1990; Langlois and Robertson, 1992). Industries such as telecommunications and computer hardware and software have typically been used as examples of situations where positive network externalities are a major driving force behind technological evolution and the emergence of dominant designs. Langlois and Robertson (1992) have for example used the cases of microcomputer and stereo component industries to illustrate the unique dynamics introduced into an industry when products are "modular," or when consumers can put together various subsystems themselves to create a product that fits their unique preferences. In both cases, large firms tried to create ready-made appliances to defuse the modularity inherent in the industry. These efforts failed, and companies that were best able to manipulate network compatibility with competitors and suppliers came out victors. Similarly, Barnett (1990) has drawn our attention to the "systemic" nature of the telephone industry and, through a historical account of the American telephone industry, shown that the principal challenge for all organizations is one of negotiating network externalities, as opposed to making radical innovations. Indeed, when technologies are systemic, technological change does not necessarily favor advanced organizations.

Research on network externalities carries several implications for practice. Two of the most commonly recognized implications are that licensing out technology deters the entry of new potential standards, and that the creation of a large number of suppliers providing compatible products increases the costs of entry to potential competitors (Wade, 1995).

Path dependency thus explains the adoption of less-efficient solutions in terms of a sequence of random events, which end up having a disproportionately large influence on the eventual outcome. Tushman and Rosenkopf (1994) on the other hand, allude to the existence of more systematic processes behind dominance but do not present a coherent explanation of what these 'socio-political' processes are. The question remains: What is the role for organizational strategy then? Tushman, Anderson and O'Reilly (1997) have emphasized that in order to maximize the probability of success, firms should engage in continuous as well as discontinuous research -- or what is referred to as"ambidextrous organization" -- and to do so simultaneously. But is there a guiding framework that managers can follow to negotiate their way through the apparent chaos that characterizes eras of ferment? Obviously such a framework can only be established in the presence of a causal explanation of technology selection. Arthur (1989) as well as Rosenkopf and Tushman (1994) have stressed the need for more empirical research geared towards exploring the underlying causes of technology selection. Seeking such an explanation, we ask:

Q 2. Do dominant designs 'emerge' randomly, through some complex, unpredictable 'socio-political' process, or are they 'constructed' systematically? What role does strategy play in the process through which a design emerges as dominant?

Interpretive Explanation of Technology Selection

Researchers using more interpretive perspectives have made substantial headway in explaining the technology selection process. Notable among them is the work done from a social constructionist perspective (Hughes, 1983; Bijker and Law, 1992; Bijker, Hughes and Pinch, 1987; Law and Hassard, 1998) and a co-evolutionary point of view, which implicitly draws on Giddens' (1984) theory of structuration as well as institutional theory (Garud and Rappa, 1994; Van de Ven and Garud, 1994).

Social constructivists (Hughes, 1983; Bijker and Law, 1992; Bijker, Hughes and Pinch, 1987; Law and Hassard, 1998) deem technological evolution to be intimately related to the construction of social structures. Technology is understood to mirror society. Various technologies reproduce and embody the complex interplay of professional, technical, economic, and political factors – the idea of a pure technology is nonsense. Technologies are always considered as embodying compromise. Politics, economics, theories of strength of materials, notions about what is beautiful or worthwhile, professional preferences, prejudices and skills, design tools, available raw materials, theories about the behavior of the natural environment – all of these are thrown into the melting pot whenever an artifact is designed or built. Technologies do not evolve under the impetus of some necessary inner technological or scientific logic. They are not possessed of an inherent momentum. If they evolve or change, it is because they have been pressed into that shape by human intention or intervention. Such an approach allows for various possibilities as to how technological developments will occur. This means that technologies that are currently in the process of being developed might, at least in principle, take a variety of different forms, shapes and sizes.

Naturally, social constructivist arguments come into sharp conflict with those of technological determinists who essentially believe that better technologies eventually prevail. The determinist perspective is rooted in neo-classical or industrial organization economics disciplines (Carter, 1984; Davis, 1989; Dosi, 1982; Utterback, 1994). Extreme views in this perspective view technology as "an irreducible brute fact, a given, a first cause, rather than as hardened history, frozen fragments of human and social endeavor" (Noble, 1984, p. xi). Such a view ignores the social content of technology and assumes that technology constitutes completely codifiable knowledge with well-defined capabilities and limitations. Thus, comparison among various technologies is easy. Technological evolution then becomes a matter of pure technical interest: the better technology will eventually succeed. Scholars subscribing to a technologically determinist approach treat each technological advance as a technological imperative, portraying technology as an exogenous and autonomous development, which coerces and determines social and economic organizations and relationships (not necessary Orlikowski, 1992 or Grint and Woolgar, 1997). Technological determinism appears to advance spontaneously and inevitably, in a manner resembling Darwinian survival in so far as only the most "appropriate" innovations survive and only those who adapt to such innovations prosper.

These 'over-socialized' and 'under-socialized' views of technology evolution are reconciled by the 'co-evolutionary' perspective on technology (Barley, 1996; Garud and Kumaraswamy, 1993). Garud and Kumaraswamy (1993) and Van de Ven and Garud (1994), among others, have argued that technologies transform in their interaction with social institutions. Thus, from its birth to its acceptance, a technology undergoes a social transformation, defining itself through its new associations, and evaluating itself on newly established criteria. This view is itself an advancement over early institutional theory, which treated technological and institutional environments of the firm separately. These theories noted that organizations confront either technical or institutional environments, each exerting different types of pressure. However, more recently, institutional theorists have realized that the distinction between technical and institutional environments is a false one. They then proposed that organizations may simultaneously be subject to strong technical and institutional pressures. In particular Scott and Meyer (1983) proposed that contradictory demands placed by these environments on organizations would lead to higher levels of internal conflict. Orru, Biggart, and Hamilton (1991) among several others, however, challenge this view. Instead they suggest that institutional pressures themselves are essential for the emergence of market order. Indeed Powell (1991) and Dobbin (1995) argue that institutional environments set the very criteria against which technical efficiency is judged (Barley 1986; Orlikowski, 1992), a point underscored in Garud and Kumaraswamy's (1993) study of network industries.

In recent years, evidence has accumulated that such transformations occur routinely after radical technological discontinuities because of the ambiguity of expectations witnessed at such times. While it may be easy to distinguish between superior and inferior technologies in the case of incremental innovations such as in the case of an auto-focus lens vs. a manual focus lens, radically different designs competing during an era of ferment present an altogether different case. In this case, we cannot assume that consumers can compare the price/performance ratios of various competing designs because performance of each design is often measured through completely different evaluation routines (Christensen, 1997; Garud and Rappa, 1994). In case of radically new technologies, consumer expectations are as much shaped by new designs as the designs are shaped by firms' understanding of consumer needs (Cusumano, Mylonadis and Rosenbloom, 1992; Christensen 1997). Immediately after a radical discontinuity, consumer expectations are largely unspecified, ambiguous and constructed within the existing technological paradigm (Christensen and Bower, 1996; Christensen, 1997; Schilling, 1998).

The above studies imply that technology, or at least its value, is constructed as much in the market as it is in the laboratory. How this process unfolds is central to this research.

Q3. How do evaluation criteria, used to assess technological superiority, change? What is the role firm-level strategies play in this process?

The Dynamics of Technology Substitution

While a few researchers have utilized insights from neo-institutional theory to explain technological change (Garud and Kumaraswamy, 1993), it remains primarily an interpretive perspective with the capacity to provide many important insights into the process /by which a new technology replaces an old one. This is despite the fact that neo-institutional theory is not usually regarded as a theory of organizational change, but as usually an explanation of the similarity, or "isomorphism", and stability of organizational arrangements in a given population or field of organizations. Ledford, Mohrman, Mohrman, and Lawler (1989: 8), for example, concluded that institutional theory offers not "much guidance regarding change." Buchko (1994: 90) observed that institutional pressures are "a powerful force" against transformational change. However, I present the opposite view in line with arguments presented by Dougherty (1994) and Greenwood and Hinings (1996) that institutional theory contains an excellent basis for an account of change. As Greenwood and Hinings (1996) suggest, however, formulated, neo-institutional theory offers a weak analysis of the internal dynamics of organizational change. Nevertheless, neo-institutional theory contains insights and suggestions that, when elaborated, provide a model of change that links organizational context and intra-organizational dynamics.

Institutionalization is the process through which actions, norms, beliefs, and meanings of various symbols come to be shared by a community. An institution is then a social pattern that reveals a particular reproductive process. When departures from the pattern are counteracted in a regulated fashion, by repetitively activated, social constructed, controls – that is, by some set of rewards and sanctions – we refer to a pattern as institutionalized (Jepperson, 1991: 145). Institutionalists argue that organizational decisions to adopt new practices or technologies are not driven solely by economic and technological reasons, but that the social and cultural milieu in which the organization finds itself plays a key role in determining what practices come to be adopted (Tolbert and Zucker, 1983; 1996). In fact, Scott (1987) maintains that this social and cultural environment is instrumental in shaping the goals of organizations and serves to legitimize or delegitimize the means that are used to attain these goals. Organizational forms or practices are only stable when they assume a normative role in the society in which they exist.

According to institutional theorists, potential adopters of a practice have their choice set constrained by regulative, normative and cognitive institutions by which they live their lives. These constraints are called the three institutional pillars (Scott 1995). Regulative institutions include institutionalized understandings of government policy, infrastructural constraints, bureaucratic requirements and so on. Normative pressures are values and norms which introduce a prescriptive, evaluative, and obligatory dimension into social life. Consider, for example, the case of a job description. It cannot possibly cover all aspects of a person's life at work. The aspects that are left unarticulated are decided through normative and cognitive institutions in the organization or society. Similarly, a person's interaction with technology is inevitably dictated in part by the norms of the organization or the immediate environment. An example of a norm could be as simple as a concern for quality. Over time, each organization develops its own norms regarding quality and a management decree cannot ensure quality consciousness overnight. Norms also determine what method or activity is preferred or desirable as well as how it should be done. These also decide the behavior expected from any individual taking into account his position within or outside of the organization, his profession, and a host of other socially known details about him.

Finally, cognitive pressures are those which determine the extent to which wider belief systems and cultural frames are imposed on, or adopted by, individual actors and organizations. Although individuals continuously negotiate social reality in everyday life, they do so within the context of wider, preexisting cultural systems;symbolic frameworks, perceived to be both objective and external, that provide orientation and guidance (Goffman, 1974). Thus, readymade classifications such as social identities, or conceptions of who we are, guide our behavior within and out of organizations (Douglas, 1986). Consequently, individual behavior often reflects external definitions rather than internal intentions. Compliance occurs in many circumstances because other types of behavior are inconceivable.

Decisions to adopt a new technology or practice, then, are influenced by three kinds of pressures: regulative, normative and cognitive. As Garud and Kumaraswamy (1993) have suggested, these institutions co-evolve with new technologies, leading to a mutually supportive arrangement where the institutions support the dominant technology in an organizational field, and vice versa. Giddens elaborates on this process through his concept of structuration. According to Giddens (1984), institutional fields develop through a process of *structuration*, where patterns of social action produce and reproduce the rules and resources that constitute the field (Giddens 1984; Whittington 1992). As DiMaggio and Powell explain:

> The process of institutional definition, or "structuration", consists of four parts: an increase in the extent of interaction among organizations in the field; the emergence of sharply defined inter-organizational structures of domination and patterns of coalition; an increase in the information load with which organizations in a field must contend; and the development of a mutual awareness among participants in a set of organizations that they are involved in, in a common enterprise.' (DiMaggio and Powell, 1983: 148)

Giddens' structuration view, in particular, may serve to reconcile the dichotomy between institutions and technology found in earlier institutional theory (Orlikowski, 1992). Giddens (1979, 1984) has attempted to reconcile the conception of structure as form and structure as process by proposing that structure be viewed as a duality: that action is both "constituted by" and "constitutive of" social organization; "that the structural properties of social systems are both the medium and the outcome of practices that constitute those systems" (Giddens, 1979: 69). From Giddens' perspective, although one can emphasize one or the other aspect of the dual reality -- action defining structures or structures constraining action -- of greatest importance is the interplay between the two. As stressed by Barley, "through this interplay, called the process of structuring, institutional practices shape human actions which, in turn, reaffirm or modify the institutional structure. Thus, the study of structuring involves investigating how the institutional realm and the realm of action configure each other" (Barley, 1986: 80).

Accordingly we may argue that nascent technologies are institutionalized only through interaction with existing 'regular' structures. Regular structures are simply entities that lend stability, continuity and value to a nascent design. These comprise both of agents and inanimate resources or schemas. As the choices that agents make in all situations is a function of structural influences on agents' actions, all structural influences on a potential adopter's decisions are relevant to the adoption of any new technology. Formally, Giddens defines structures as "rules and resources, recursively implicated in the reproduction of social systems" (1984: 377). Thus the concept of structure refers to any factor that influences action (Giddens, 1984). However, structures are differentiated from a general set of contingencies by the regularity that they possess (Mauws and Phillips, 1998). In other words, they are influences that are relatively stable (e.g., Collins, 1981). When a dominant design has not yet emerged, the important regular structures could constitute the existing rules governing relationships among industry members, jointly adopted standards, brand names, or technological artifacts along with any number of other structures which may become relevant with time. On the other hand, a newly introduced technology, however advanced, is not a regular structure.

It is important to note that the relationship between social action and regular structures is a recursive one (Giddens, 1984). Through their actions, people enact and reproduce structures, and by guiding action, structures maintain regularity and predictability in social situations. Consequently, association of a nascent design with regular structures may have a regularizing effect on it. Association with a regular structure could constitute incorporation of an existing technological 'fact' within the design itself or in the usage pattern of the design, or an alliance (ranging from a simple licensing contract to a joint effort for technology development) with a discrete agent[11]. In both cases, the link must be obvious to the customer so that the nascent design can benefit from what could be called a "stability-spillover effect." In other words,

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[11] While management research has emphasized more explicit influences on selection such as compatibility, market clout, or the role of regulatory institutions, relationships of a new technology with existing technologies, social institutions, or technological 'facts' as an important influence in the selection process has largely been neglected.

association with regular structures could be expected to add regularity around a nascent design. Such an argument naturally holds substantial implications for technology substitution. For instance, it forces us to attribute much more importance to social institutions that are in any way linked to the process through which people make sense of a new technology, thus making technology evolution a social process rather than a purely technical one. It also changes our understanding of a major criticism that institutional theory is faced with: for new technologies to be institutionalized, old ones must be de-institutionalized, which leads us to question whether the old technology was institutionalized in the first place. These issues are further developed and discussed at greater length in Chapter 8, following the case studies.

Impetus for Change

Together, the institutional and structuration perspectives combine to provide key insights into the evolutionary process of social structures. However, at least one major question remains. If everything in an organizational field is institutionalized, critics ask, where does the impetus for change come from? Leblebici, Salancik, Copay and King (1991), argue that chances are the regulative, normative and cognitive institutions that sustain a particular technology suit the dominant players in an organizational field. As Meyer and Rowan (1977) suggested, efforts to change institutional environments can proceed along two dimensions. first, powerful organizations force their immediate relational networks to adapt to their practices, and, second, powerful organizations, attempt to build their goals and procedures directly into society as institutional rules (Meyer and Rowan, 1977: 346-348). Thus in order to bring about institutional change, the change agent has to be a major institutional entrepreneur, but since their interests are isomorphic with the current situation, why would dominant players want to change the status quo at all? If they are not the ones who bring about change, who or what is the source of change?

Secondly, if one accepts Scott's (1987) argument that organizational interests as well as task requirements are institutionally defined and shaped, how does the idea of change appear feasible in the first place? An institution already specifies what should be done and how to do it. How can innovators then, realize a change is necessary or possible in an inter-organizational field with established definitions of appropriate practices? The possibility brings into question whether the practices that were abandoned for new ones were truly institutionalized, which leads us to our fourth research question.

Q4. Where is the impetus for change in institutional fields? And how is a new technological design able to replace an institutionalized one which has 'co-evolved' with existing institutions?

Causal Relationship between Technology and 'Issues'

A recent article on institutional change by Hoffman (1999) provides some insights into the problem of explaining change in highly institutionalized environments. Hoffman argues that institutional changes are triggered by disruptive events. According to Hoffman, "disruptive events can sharply end what has become locked in by institutional inertia" (p.353). Hoffman maintains,

> "...[D]isruptive events have been central in explanations of change processes on various organizational levels. They have been described as creating disruptive uncertainty for individual organizations, forcing the initiation of unorthodox experiments that diverge from established practice. They have also been described as throwing entire industries into the throes of quantum change, causing a restructuring process by the relocation of industry boundaries and an alteration of the bases of competition." (Hoffman, 1999:353)

This argument is indeed reflected in a large part of the technology management literature, which revolves around one particular type of disruptive event: a technological discontinuity. As we have seen, Tushman and Anderson (1986) have described technological discontinuities as relatively rare, unpredictable advancements in technology which often destroy existing incremental innovation patterns and threaten to render existing capabilities useless. However, whereas Tushman and Anderson seem to imply that institutional fields are created around the dominant technology, Hoffman argues that instead of technologies (or markets), institutional fields are created around 'issues,' which "bring together various field constituents with disparate purposes" (1999: 353). Inevitably, disruptive events lead to the raising of new issues, which become the nexus for the formation of a new field. The publication of Rachel Carson's *Silent Spring* in 1962, for example, had a decisive impact on environmental technology and practices by raising awareness on such issues as pesticide toxicity. This lead to the formation of an institutional field involving chemical producers, government agencies, scientific organizations and conservation groups.

The issue of institutional field formation is an important one for at least two reasons. First, it arguably influences technology evolution in the 'co-evolution' of technology and social institutions (Garud and Kumaraswamy, 1993). Second, since technologies and social institutions mutually support each other, it is in the process of de-institutionalization of existing technologies that answers to questions about how new technologies are able to uproot existing, institutionalized ones may be found. Hoffman's research strongly suggests that issues, instead of technologies, may be at the heart of field formation. However, as he admits himself, his research "could not prove a causal connection between the events detected and the institutional change that followed (1999: 367). It is the exploration of this causal connection at which our fifth and final research question is directed.

Q5. What is the causal relationship between radical discontinuities, issues and the formation of new institutional fields?

CONCLUSION

This chapter has explored the theoretical concerns that motivated this dissertation. Essentially, we are concerned with one broad problem: why and how are certain technologies able to supplant widely accepted, and deeply institutionalized ones, while others are not? Likewise, when several new designs compete against each other for dominance, what factors determine their success or failure? An overview of existing research in diverse fields provides several clues. For instance, the evolution of a technology cannot be studied independently from the evolution of the institutional field around it (Garud and Kumaraswamy, 1993). The technology, it has been argued, 'co-evolves' with the social institutions that are used by customers to make sense of it. This implies that technology is not only constructed in laboratories but also in the social arena. It is imperative, then, that we pay special attention to the 'social construction' of technologies in the public realm.

Functionality and economic efficiency are obviously important considerations in the success of a technology. While on the one hand, empirical evidence strongly suggests that at various phases in the era of ferment, different technologies look attractive from an economic point of view, on the other, it is argued that by the time, technologies achieve dominance, they are indeed the most attractive alternative by virtue of increasing returns to adoption (Arthur, 1989). Thus, it becomes important to study both the technologies that succeeded and those that failed to gain insights into how technologies acquire this superiority. Do inherent characteristics play any role in this process?

Similarly, various firm level strategies (see e.g., Teece, 1988; Cusumano, Mylonadis and Rosenbloom, 1992; Christensen, 1997) as well as particular organizational configurations (Tushman, Anderson and O'Reilly, 1997) have also been held responsible for the success of particular designs. Indeed, technologies cannot be assumed to mate on their own to generate new, unpredictable outcomes. Firms do mediate between technologies and the market, taking important, strategic decisions that profoundly influence the interaction between technology and society. Not only are their strategic considerations responsible for decisions to introduce a new, socially unsanctioned technology to supplant an existing, institutionalized one, to adopt a particular technological architecture or design, but also underlie their choice of alliance partners, licensing strategies etc.

However, this dissertation does not focus on a single determinant of success (or failure) of designs. Instead, it aims to uncover how the institutional context, the process of social construction, path dependencies, socio-political processes, design architecture and firm strategies fit together. The theoretical insights developed by past researchers, and summarized in this literature review, provide the base from which this thesis research expands. This research, however, takes these insights further, creating new linkages between them, and consequently leading to new insights.

FIGURES TO CHAPTER 1

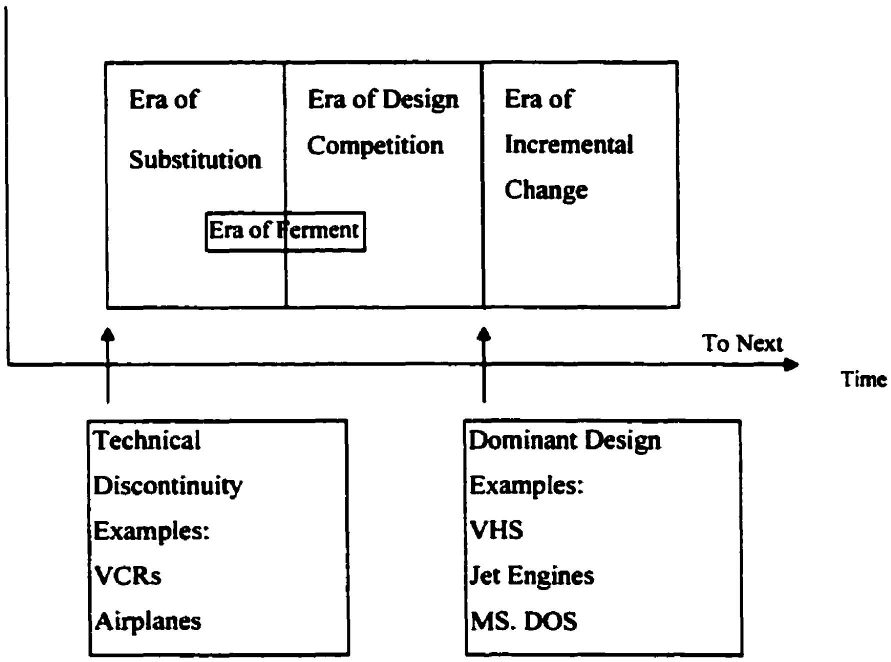

Figure 1.1 (Adapted from Anderson & Tushman, 1997)

CHAPTER 2: METHODOLOGY

While this study is essentially exploratory, its scope is nevertheless specified by a single broad concern: why and how do certain technological designs become dominant, while others, arguably superior in some aspects, cannot? The importance of this question to an academic understanding of technological evolution and managerial decision-making in 'eras of ferment' was discussed in the previous chapter. Due to its critical importance, and as discussed in Chapter 1, the question has been researched from various angles in the past and informed by new perspectives in this study.

Methodologically, the present study both borrows, and differentiates itself from earlier works. Like much previous research, my research on the photographic industry focuses on a single 'industry', treats technology as the primary unit of analysis, and is longitudinal rather than cross-sectional. At the same time, it departs from earlier research in two important respects. First, it involves studying a technology-in-making. While previous studies have provided several important insights into the dynamics of technological evolution, it cannot be denied that once a technology becomes successful, justifications for its success are relatively easy to find. Indeed, it appears almost 'obvious' why a particular technology just *had* to succeed. Knowing the result bias the study, however slightly which likely influences a researcher's decisions regarding what questions to ask, which variables or dynamics to look at or highlight and which possibilities to explore. For these reasons, Latour (1991) suggests that the best time to study a technology is during its construction. At that time, the future of the technology is wide open. Decisions are still being made regarding the material to use, the customer's needs to satisfy, the markets to explore, the standards to incorporate or adapt to and so on. Once, however, the product or design is a success, all these decisions are considered vindicated by the market as well as by researchers, mostly leading to functional explanations of technological success. On the other hand, while the black box of technology is still open, and the fate of the design undecided, each possibility regarding materials to be used, markets to focus on, competing customer needs to satisfy, and standards to adapt to, seems equally plausible, leading to a more objective point of view.

Secondly, the present study attempts to study technological change within the context of an institutional field, rather than an 'industry.' This expands the scope of the data to be collected and the factors that need to be considered when evaluating technology evolution. Moreover, what makes this study particularly rich is the fact that the activity of photography represents a point where several technologies as well as industries converge such as chemicals, mechanics, optics, electronics, photo-finishing and so on. It thus contains the richness, complexity and depth essential for building theory.

Finally, the activity of photography also represents a cultural experience. Cameras have evolved from status symbols to functional tools to "cool" devices. The meaning attributed to this technological artifact has shifted over the years with social changes. Thus, the industry offers a remarkable site for exploring how the social affects the technical, and vice versa. Indeed, Rosenkopf and Tushman (1994) have stressed the importance of studying technological changes where institutional forces in the social domain strongly affect technological development.

Despite these differences, readers would find themselves familiar with to several features of this research. Its longitudinal focus on a single industry, and technology as unit of analysis are standard practices in research on technology management. There are good reasons for choosing to focus on a single industry. While we must of course be circumspect about generalizing conclusions drawn from the study of a single industry, such studies when they span several years also present clear advantages for theory building that studies based on cross-sectional data are unable to provide. For example, cross-sectional data are not able to take into account the fact that processes emerge in particular historical settings. Studies conducted in any one point in time assume there are no period effects (Mason and Fienberg, 1985). With longitudinal data, Blossfeld (1986) has shown that period effects can be identified.

Similarly, cross-sectional data do not provide an adequate opportunity for the study of how changes in group-contexts influence the dependent variable or the process under study, at different levels (Mayer and Tuma, 1990). Moreover, cross-sectional data are inherently ambiguous with respect to their interpretation at the level of the unit of observation. They miss out on duration dependence. From an analytical point of view, it is important to have data about duration in a particular state. For example, if a design is dominant for a much longer period of time than others, it would normally not be apparent in cross-sectional data. Finally, cross-sectional models very often have a tendency to over-predict change and consistently overestimate the importance of explanatory variables (Davies, 1987). The reason for this phenomenon is that these analyses cannot be based on how changes in explanatory variables engender changes in outcomes. They are only concerned with how levels of explanatory variables explain an outcome at a specific point in time.

Collecting longitudinal data on an industry allows us to build much greater familiarity with the socio-economic context and temporal patterns of the focal changes. An intimate familiarity with the context is essential when making sense of non-factual data. Indeed, uncovering/using/applying data concerning motivational, attitudinal, cognitive, or affective states could be particularly problematic if not put in the context in which these occurred. However, longitudinal data drawn from multiple archival/ published sources can largely eliminate these problems.

Perhaps it is for these reasons that in-depth case study analysis of a single industry is standard practice in the technology literature. For example, Rosenkopf and Tushman's (1994) findings were based on the analysis of the flight simulator industry; Christenson (1992) studied the disk drive industry; Burgleman's (1994) findings were based on an in-depth analysis of the microprocessor industry; while Garud's (1989) data derived entirely from the chochlear implant industry. More recently, Tushman and Murmann (1998) used the aerospace industry to develop a grounded theory of nested designs. While some of these studies involved interviewing managers about current strategies (Burgleman, 1994), or about data collection over a long period of time (Garud, 1989), others based their findings on historical events (Rosenkopf and Tushman, 1994; Christensen, 1992; Tushman and Murmann, 1998).

In the present study, a single-industry longitudinal case study is especially desirable because of the need to tie the several - sometimes irreconcilable, yet pervasive - insights into technology evolution in the literature. Casting the net wide to an institutional context rather than a narrowly defined 'industry', and building the research on insights from diverse perspectives from path dependence to social construction leads to a richer and broader theory of technology evolution than would result from research with a narrower scope.

A Note on the Historical Focus of this Study

This dissertation is essentially based on archival research. Surprisingly, despite the historical orientation of such founding fathers of modern-day social science as Karl Marx, Emile Durkheim, and Max Weber, much of social research during the past half century has lacked a historical focus. Indeed, from the time of Schumpeter (1954) to Porter (1990), scholars have emphasized the need for a greater historical focus. Schumpeter, maintains,

> Most of the fundamental errors currently committed in economic analysis are due to a lack of historical experience more often than to any other shortcoming of the economist's equipment... (Schumpeter, 1954: 13)

And Michael Porter concurs,

> "I concluded in my most recent research that detailed longitudinal studies, covering long periods of time, were necessary to study [competitive success]... This style of research nudges strategy research, and indeed industrial economics, into the world of the historian." (Michael Porter, 1994).

Finally, closer to home, DiMaggio has also emphasized the need to put things in a historical perspective,

> "Explaining many things about the coevolution of populations in a community requires narrative history as a complement to statistical analysis." (DiMaggio, 1994: 446).

In this research, seventy five percent of the cases studied were historical, and situated along a temporal continuum. Knowing the history of a case proved to be a distinctive advantage. Not only was I able to appreciate the technology better because of my knowledge of its origins and evolution, but I also found myself much better equipped to ask intelligent, appropriate and incisive questions to industry executives. For instance, I found that those I interviewed, despite being senior executives, were unaware that Kodak's first attempt to launch roll-film cameras was a failure. Instead they believed that roll-film technology was a hit as soon as it was introduced, because it met customer needs. My knowledge of Kodak's initial failure, subsequent success and the reasons for this made a positive impression on the executives, enhanced the depth and quality of our discussions, and who then provided the impetus for their thoughtful and well-considered responses.

RESEARCH DESIGN

This research relies heavily on Eisenhardt's widely used template for generating theory based on case study research (Eisenhardt, 1989). Eisenhardt argues that case studies are valid tools for the accomplishment of various aims including providing description (Kidder, 1982), testing, modifying or furthering existing theory (Pinfield, 1986; Leblebici et al, 1991), or generating theory (Gersick, 1988; Harris and Sutton, 1986; Tushman and Murmann, 1998). One strength of building theory from cases is its likelihood of generating novel theory:

> Creative insight often arises from the juxtaposition of contradictory or paradoxical evidence.... The processes of reconciling these contradictions forces individuals to reframe perceptions into a new gestalt. Building theory from case studies centers directly on this kind of juxtaposition. That is, attempts to reconcile evidence across cases, types of data, and different investigators, and between cases and literature increase

the likelihood of creative reframing into a new theoretical vision. Although a myth surrounding theory building from case studies is that the process is limited by investigators' preconceptions, in fact, just the opposite is true. This constant juxtaposition of conflicting realities tends to 'unfreeze' thinking, and so the process has the potential to generate theory with less researcher bias than theory built from incremental studies or armchair, axiomatic deduction" (Eisenhardt, 1989: 546).

Secondly, according to Eisenhardt, theory generated from cases is likely to be testable with constructs that can be readily measured and hypotheses that can be proven false. Since the theory is based in empirical evidence, constructs have already been identified and verified during the several iterations that case studies necessitate. This is in sharp contrast with the measurability problems posed by theories generated from non-empirical experience. For example, Eisenhardt argues the niche concept, borrowed by population ecology researchers from biology has proven difficult to operationalize for many researchers.

Finally, maintains Eisenhardt, a third strength of theory generated from case studies is its likely empirical validity. Since the theory-building process is so intimately tied with evidence, it is very likely that the resultant theory will be consistent with empirical observation. In well-executed theory-building research, investigators answer to the data from the beginning of the research. This closeness can lead to an intimate sense of things – "how they felt, smell, seem" (Mintzberg, 1979). As Eisenhardt puts it: "This intimate interaction with actual evidence often produces theory which closely mirrors reality" (Eisenhardt, 1989: 547).

Research Questions

Eisenhardt has emphasized that an initial definition of the research question, in at least broad terms, is important in building theory from case studies. Defining the research question as specifically as possible decreases the probability of 'drowning in data' which can easily occur in the face of mountains of rich data which complex situations inevitably offer. In our case, the questions were driven by one primary concern: ***Why and how do some technologies emerge as dominant following a radical discontinuity, while other, equally plausible candidates are left behind?***

This question was further carved up to cover other possible scenarios such as when, for instance, there is only one new proprietary design, which is introduced to supplant an existing, institutionalized technology - and explore leads that diverse perspectives have offered such as the co-evolution of social institutions and technology, or the social construction of technology. In total, I pose five related research questions which question, from various angles, the dominant design phenomenon . The first question is directed at assessing technologies immediately after a radical discontinuity. The second question is directed at discerning both systematic patterns in the evolutionary process across cases as well as the role of strategy. The third question is aimed at exploring the change, if any, in the evaluation criteria used to assess technologies through the era of ferment as well as the role of strategy in changing them. The intent of the fourth question, is to explain the institutionalization and de-institutionalization of technology, and finally the fifth question, is posed to explore Hoffman's (1999) suggestion that issues, not technologies, in fact form new institutional fields, fields which inevitably emerge after a radical technological discontinuity results in a new dominant design.

Defining the Constructs

Eisenhardt has emphasized the importance of a priori specification of constructs since it can "help to shape the initial design of theory building research" (Eisenhardt, 1989: 536). Eisenhardt acknowledges that while early identification of possible constructs is helpful, it is equally important to recognize that both are tentative in this type of research. No construct is guaranteed a place in the resultant theory, no matter how well it is measured. Furthermore, the research question may shift during the research. Finally, Eisenhardt emphasizes, theory-building research is begun as close as possible to the ideal that there is no theory under consideration and no hypothesis to test.

While this research design does not conform to the ideal of beginning with no theory or suspicions, it does come quite close to it by its reliance on several different perspectives rather than one single overarching one. Reliance on wide ranging perspectives raises the probability of covering all bases, at least to begin with. Indeed, as has been the experience with most case-based research, new bases are inevitably established in the course of exploring older ones. My experience was similar. While I started out with the questions listed above, by the end of data collection I had developed several new questions that I weave into my synthesis in the final chapter, which follows the case studies. The new issues thus establish new bases to be covered by researchers in future research on technology evolution.

The questions listed above require defining some major constructs around which this research revolves. They are: institutional fields, technology, practices, framing and enrollment.

Institutional Field

"An institutional field is a community of organizations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside the field" (Scott, 1995: 56). The concept of "institutional field" is thus a much broader and more dynamic concept than "industry" which is typically bound on the basis of SIC codes. As Leblebici et al maintain, "the organization of an institutional field is a product of practical solutions developed at the micro level and institutionalized through conventions at the macro level. This organization, however, is not permanent but temporary and is only one among many possibilities. Its production and reproduction is an outcome of institutionalized definitions of what is being transacted" (Leblebici et al, 1991).

Institutional fields become "arenas of power relations" (Brint and Karabel, 1991: 335) where multiple field constituents compete over the definition of issues and the forms of institutions that will guide organizational behavior. Institutional beliefs and perceptions are influenced by this field-level competition but are situated within individual organizations or populations of organizations. Therefore, to fully apprecieate the complexity of institutional dynamics, one must analyze both the specific institutions that lie at the center of an issue-based field and the competing institutions that may lie within the individual populations that inhabit the field (Hoffman, 1999).

According to Scott (1995) institutional fields rest on three pillars: regulative, normative and cognitive institutions.

1. **Regulative Institutions**:

Regulative (or legal) aspects of institutions most commonly take the form of regulations. They guide organizational action and perspectives by coercion or threat of legal sanctions. Organizations accede to them for reasons of expedience, preferring not to suffer the penalty for noncompliance. For example, firms may relinquish control of strategic information, say, photofinishing techniques for a new film to avoid charges of anti-competitive behavior. Similarly, firms may not introduce their technological designs in the market for the fear of infringing on existing patents.

2. **Normative Institutions**:

Normative (or social) aspects of institutions generally take the form of rules-of-thumb, standard operating procedures, occupational standards, and educational curricula. Their ability to guide organizational action and beliefs stems largely from social obligation or professionalization. For instance, after working in a particular business for several years, workers may internalize the deep-seated assumptions about customer needs and behavior that guide organizational action or technology strategies. In the imaging industry, it is 'normal' to list image quality and price as the ultimate evaluation criteria for consumers. Technological efforts are all consequently directed accordingly. Other normative institutions may include the popular understanding that photography requires buying film and paying for the development and printing of photographs by photofinishers. Thus, routines established around certain practices may be considered normative institutions , for example, even novices know where to buy film and where to drop it off for development.

3. **Cognitive Institutions**:

Cognitive (or cultural) aspects of institutions embody symbols – words, signs, and gestures – as well as cultural rules and frameworks that guide understanding of the nature of reality and the frames through which that meaning is developed. Organizations will often abide by them without conscious thought (Zucker, 1983). Cognitive institutional aspects form a culturally supported and conceptually correct basis of legitimacy that becomes unquestioned. For example, it is automatically assumed that photography is practiced principally to preserve memories, that people will always want hard prints of their photos, and that people mostly want to photograph their loved ones and sights seen on a vacation, or anything of 'interest'. Moreover, a clear, in-focus photograph is considered a 'good' photograph.

Technology

Technology is defined here as the tools, knowledge and methods that allow agents in a field to deliver on their claims. It is a complex system of engineering and scientific knowledge, techniques, arrangements of equipment, and networks of operating subsystems (Dougherty, Borrelli, Munir and O' Sullivan, 1999). Naturally, any particular technology embodies beliefs about scientific/technological possibilities, understandings of the market, evaluation routines, constraints within and without the organization and any other assumptions made by its designers (Orlikowski, 1992).

Practices

Practices are agents' specific actions within an institutional field. Theoretically, we assume that practices are voluntary and not required. At any point in time participants can act otherwise, either by choosing an alternative action or by choosing not to act. Actors always have discretion and are not passive agents acting under complete constraint.

Organizational practices are institutionalized when they are adopted because actors take them for granted rather than because a rational choice process found them to be best suited for the technical requirements of the task. Judgements of appropriateness are not based solely in individual cognitions, but follow from cognitive structures, such as scripts and schemas, that are more-or-less shared across societies (DiMaggio and

Powell, 1983). Moreover, notions of appropriateness impose what is in effect a cognitive viability test on organizational forms and practices. While a variety of social structural arrangements may be possible and technically adequate in principle, to be adopted they must be cognitively "available" to the relevant actors – to both potential adopters and those providing resources. What is available, as well as what is ruled out, follow in part from what has gone before. Thus, imitation and rule-following reduce some of the "cognitive start-up costs" for organizations (DiMaggio and Powell, 1983).

Evaluation Criterion

Garud and Rappa (1994) have suggested that technological designs co-evolve with evaluation routines. Evaluation routines are described as methods employed by researchers or inventors to test or validate a technology. Existing routines perpetuate existing technologies. At the organizational field level, evaluation routines are transformed into evaluation criteria. These criteria are in fact measures of how well a particular technology meets a valued end. In case of radically new technologies, prevailing evaluation criteria invariably favor existing dominant designs (Christensen, 1997). Thus, under prevailing evaluation criteria, a radically new design cannot demonstrate its true potential, and unless it does so, attracting others to participate in developing the technology to a more advanced state is not possible. The only way out of this catch-22 situation is intervention by organizations to create a new set of evaluation criteria that favors the new technology.

Framing and Enrolment

By the end of the data collection, it was evident that these constructs were not enough to explain how technologies achieved dominance. Thus, in the discussion chapter,(which is the discussion chapter?) I introduce two new constructs: framing and enrolment. Framing is simply the sponsor's attempt to define the central issue in the field. For instance, the central issue before customers could be described as image quality, as the dry plate companies did, or convenience, as Eastman Kodak did, at the turn of the 20th century. Similarly, the issue now could be quality, which, ironically, Eastman Kodak is now emphasizing or connectivity, which Sony is stressing. Issues mobilize investment, commitments to particular technologies and decide the configuration of inter-organizational alliances and relationships around which a field emerges.

Enrolment, on the other hand, is simply a mechanism through which a design assumes the central position in a growing network of agents as well as other technologies. While in most management theory, 'enrolment' commonly signifies membership of a network or alliance (Nohria and Eccles, 1995), I use it in the sense that actor network theorists do (Latour, 1991; Law, 1991). From this perspective, enrolment means building an explicit relationship with an agent or an artifact in order to borrow its support and make it part of the network which supports a particular claim. Thus, a large technological community such as the one that developed around electric power networks (Hughes, 1983) constitutes an actor-network, as does the community formed around the Windows operating system (Wade, 1995). In this view, understanding large socio-technical systems involves understanding how collective activities are created and sustained over long periods of time and across a diverse set of interacting communities. These networks are composed of humans, artifacts or technologies. A nascent technology can gain support by enrolling the support of agents as well as existing institutions. An agent is assumed to be enrolled when it agrees to adhere to the technological standards, procedures, or routines that would enable the focal actor to deliver on its claim (thereby institutionalizing the nascent technology). On the other hand, an artifact is assumed to be enrolled when it, and its associated routines, become linked to the nascent technology. This can be done by incorporating an existing technology either within the core of the new technology or peripherally. Through framing and enrolment, players strive to alter the meaning system surrounding a technology, thus creating new evaluation criteria.

CASE SELECTION

Population

Naturally, selection of cases is a critical aspect of building theory from case studies. After all, choice of a sample determines several aspects of the study before it even begins. As Eisenhardt (1989) stresses, the choice of cases when developing theory from case study research is unusual; cases are chosen for theoretical not statistical reasons (Glaser and Strauss, 1967). The cases may be chosen, argues Eisenhardt, to replicate previous cases or extend emergent theory. Naturally, they may also be chosen randomly, although that is "neither necessary, nor even preferable" (Eisenhardt, 1989: 537). As Pettigrew (1988) noted, given the limited number of cases which can usually be studied, it makes sense to choose cases such as extreme situations and polar types in which the process of interest is "transparently observable." Thus, the goal of theoretical sampling is to choose cases which are likely to replicate or extend the emergent theory. Several authors studying technology evolution have used theoretical sampling. For instance, Christensen (1997) studied several cases of technological discontinuities within the disk drive industry because of characteristics that were unique to the industry, but relevant to the research question that he wished to explore. Similarly, Rosenkopf and Tushman (1994) studied several cases that highlighted the focal phenomenon and the emergence of dominant designs. Finally, Schilling (1998) studied several cases of technological 'lock-out' using a theoretical sample rather than a statistical one.

The 'photographic industry[12]' (now known as the 'imaging' industry) was selected as the population for theoretical reasons. First, it is in the throes of change, as this dissertation is being completed, and thus offers a fascinating arena for observing the dynamics of technological change. While the industry has experienced several radical discontinuities in the past, the change that this industry is currently going through is unprecedented in its magnitude and direction. The advent of digital imaging technology, initially brought in by an unknown in this industry, Sony, has led a host of new entrants into the industry, each challenging the incumbents fiercely organized around the traditional chemical-based image processing technology. However, chemical technology has provided, and still provides, the bread and butter for millions in this industry who are either involved in producing 35mm films, various cameras which utilize those films, or independent photoprocessing. The bulk of the profits for the largest companies in the industry, Kodak and Fuji Film, comes from sales of 35mm film. Even Kodak, which

[12] The photographic industry comprises firms manufacturing cameras, film, various kinds of lenses, photographic paper, chemicals used in developing and printing, various accessories such as flash bulbs, filters, tripods, camera cases, as well as several thousand retailers and photofinishers.

invented the roll-film, has repeatedly failed to replace it with cartridge or disc. But for the last ten or so years, a completely new technology has been making inroads into this industry, providing an alternative that many suggest would become *the* way of taking pictures in the future.

Though it offers convenience and enormous room for later manipulation, the quality of images produced digitally is still weak. Therefore, three broad technologies are currently operative in the market: traditional chemical-based photography which still produces the most accurate images; digital technology by which one can store digitally produced images onto discs loaded into the computer or download the images on to a PC; and last are hybrid technologies whereby images captured on traditional film are downloaded onto CDs rather than on paper and then manipulated on computers.

As discussed above, this industry has experienced several technological discontinuities over its 160-year history, thus providing significant variance to check the propositions that emerge from this study for "generalizability" is this a word?. Finally, it meets the criterion set by institutional theorists (DiMaggio and Powell, 1993) and technology management researchers (Rosenkopf and Tushman, 1994) for future studies of technological change. Both streams of research have emphasized the need for studying situations in which 'social' forces can be expected to play a potent role, and since photography is essentially a social activity, this industry offers a remarkable site for exploring how the social affects the technical and vice versa.

Cases

While I initially planned to conduct a single, open-ended case study on the rise of digital imaging, I later added three more cases to make my argument more substantive and to allow pattern-matching across cases. However, as a multiple case-study methodology requires, every case serves a specific purpose within the overall scope of inquiry. It must be noted that while Yin (1994) recommends a replication logic for case studies, the cases in this study cannot be considered exact replications, as would perhaps be possible in an experimental setting. The temporal and physical difference between the technological changes studied makes it impossible. However, since the phenomenon being studied is the same in all four cases, pattern-matching was possible and, indeed, systematic patterns were discerned in all cases, even if some aspects were more emphasized than others in each. Later on, the theory can be further developed and tested across several industries.

The history of the photographic industry offers several interesting junctures where radical discontinuities occurred and, after prolonged periods of fermentation, produced one technology, which came to dominate the industry until the next one came along. In each instance, several designs competed for acceptance in the marketplace with varying degrees of success (for a detailed list of discontinuities please refer to Chapter 3). Not all new technologies ended up becoming dominant designs, however. For example, disc cameras introduced by the largest player, Kodak did not survive beyond 5 years of introduction. Similarly, Instant imaging had a sharp rise and then a gradual fall. Massive changes in the industry followed each case in which a new technology successfully took hold. Naturally, while it would be desirable, time constraints do not allow us to describe every single technological change in this industry. Instead, I chose four cases of technological change that covered success as well as failure and allowed me to explore the various aspects of technological change outlined in the research questions.

Each case studied had unique characteristics and was situated in a different context, both technologically and temporally, while being in the same 'industry'[13]. While all cases contribute to building the same theory, each emphasizes some aspects particularly well. The digital imaging case, for instance, serves to highlight the different strategies adopted by various players to shape technological evolution to their own advantage. The roll-film camera case is situated almost 100 years in the past. It highlights Kodak's 'social strategy' adopted to change the context for their new technology exceptionally well. Polaroid illustrates the importance of design/ architecture and product platforms in perpetuating a particular technology. Finally, the disc camera case is useful in understanding the dynamics behind an unexpected failure.

The criterion for selecting the cases was simple. They had to span the two 'ideal types' of technological failure and success. The roll-film camera provided the first ideal

[13] By the end of this research, I found institutional field was a much stronger construct than industry,' which is defined as a group of firms producing substitute products.

type. This design has been dominant for the last 100 years, although the film format has been changing. For the last 40 years, the 35mm roll-film camera has comprehensively dominated the industry. The second case which illustrates an "ideal" failure is represented by the disc camera, introduced by Kodak in 1982 with much fanfare. It was intended/thought to be the camera of the future. In a bold move, Kodak tried to cannibalize its own 35mm camera system with smaller, cheaper cameras, which utilized discs rather than film. The design was a comprehensive failure;in 1989, its production was discontinued. This was surprising given the initial rave reviews the design received and Kodak's enormous clout.. In between the two, we have the case of Instant imaging, specifically the SX-70 design by Polaroid, which was at first an enormous success but then gradually receded into the background, having failed to stake a claim to dominance, in the same vein as the Apple Computer Company. Last, is the contemporary case of digital imaging, a competence-destroying discontinuity. The change that this new technology threatens to bring would be unprecedented in its magnitude and direction. How meaning is being created around this technology, and how it is evolving while interacting with emerging social structures is a fascinating example of the structurational nature of technological change.

DATA COLLECTION

Theory building from cases requires joint collection, coding, and analysis of data (Glazer and Strauss, 1967). As data collection proceeds, a new focus may emerge as a result of the pattern recognition or simply because of the new perspective that the researcher progressively develops on the phenomenon under study.

When I started this research, my familiarity with the photographic industry was limited to an interest in photography. I did realize that a tremendous change was underway in the industry, which offered an excellent opportunity to study a technology-in-making, in other words, a real-time account of the emergence of a dominant design. Not knowing where to start, I jumped into the wrong end of the pool: professional photography. I opened the yellow pages and proceeded to set up appointments with several professional laboratories. While I found myself on a steep learning curve, absorbing new facts about the industry at every meeting, it also became clear to me that professional photography did not account for more than 7-8% of total sales in this industry. The real 'action' was in the amateur market, and there my interviewees could not help me much. One of my contacts did, however, draw my attention to a meeting of the emerging photographic industry players in Canada near Montreal, Quebec. I duly registered for it, and discovered that this meeting too, was geared towards the professional segment of the market. I was, however, able to make some contacts who I later interviewed.

Interviews

In February 1999, I attended the annual Photo Marketing Association International (PMAI) conference in Las Vegas. This was a stepping stone in my research, and I strongly encourage future researchers to attend such industry/trade conferences in the beginning of their research. This conference provided me with instant access to scores of senior industry executives, who otherwise would have taken several months to find. While I talked briefly with some of them during the conference, mostly I exchanged cards and called them up on my return to Montreal. Since they had already promised me some time, in most cases, they were willing to spend 1-2 hours with me. I found that their willingness to give me time depended upon their assessment of my knowledge of the industry. As already mentioned, my familiarity with the history of the industry was a big factor in obtaining well-considered replies from them (Appendix 1 lists the executives that I interviewed with their position and affiliation).

The interviews were semi-structured and consistent; in each, I made sure to probe the interviewees' observations and opinions on the digital revolution and asked them to explain the longevity of traditional photography, the case of the digital camera and the success/ failure of Polaroid. As much as possible, I tried to assess how they 'understood' the technology, rather than how they 'described' it. Often this required debating with them, rather than just listening. Upon being confronted by my refusal to admit their argument, they would be forced to re-think their responses[14]. While I normally allowed interviewees to digress or go on tangents, I made sure that they did not evade the real question.

Interviews were instrumental in getting the research off the ground. I was able to ask industry contacts for publications, industry associations, past reports and so on. . At the same time, they helped me build a minimum understanding of the industry before I plunged into the data. In most cases, however, they contributed to only one of the cases: digital imaging. Since this issue is current, not only does everyone wish to talk about it but it emerged as the most appropriate topic to discuss with them, since their knowledge was current. In the other three cases, especially the first case on roll-film technology, the interviewees could not contribute much for two reasons. First, many of them were not around in this industry when Polaroid or Disc Cameras were introduced. Second, among those who were around, it was hard to know whether their recollections were accurate or a post-fact rationalization. For this reason, I did not ask them too many questions about past events.

Archival Data

[14] This is how a typical interview proceeded:

[First call: Introduction]

Kamal Munir (KM): Hello Mr. X, my name is Kamal Munir and I am a Ph.D student at McGill University in Canada. If you remember, we met at the PMAI conference where you kindly acceded to answer some of my questions about the industry.

Mr. X: Yes, I remember. (at this point they either gave me some other time to call, or asked me to set up an appointment with their secretary).

[Typical excerpt from next conversation]

[Inevitably, I was asked about my research. I had prepared one paragraph describing my research in simple words, that I drew upon at this point].

KM: Do you think digital cameras are going to take over traditional photography?

Mr. X: Digital is definitely growing very rapidly. However, the penetration is still very limited. Most consumers still do not manipulate the images. However, that is going to change, that's one thing we know. The younger generation is growing up with the computer. For them it is just like the refrigerator. The quality has also been raised, while double megapixel cameras are coming down in price. The quality is currently acceptable at the consumer level.

KM: How long do you give it?

Mr. X: Well, they are probably never going to fully replace traditional photography, but should have made a major dent by 2005.

KM: Why can't it completely replace traditional photography?

Mr. X: Well, because digital cameras do not produce hard prints, their quality is bad and....

Archives and secondary sources provided the majority of the data used in this study. Since much of the data that I needed was not available in Montreal, I had to undertake two visits to New York in search of it. I spent a total of 95 hours in the New York Public Library System going through archival material. The initial period was quite exploratory, and involved a search for technology shifts, actions taken by organizations, sorting these into various periods for which a technology remained dominant, as detecting traces of external trends and events in the environment. Several sources of information were tapped which included existing company documents, annual reports; industry reports; trade journals; business magazines such as Forbes and Fortune; newspapers such as the New York Times and the Wall Street Journal; electronic sources such as Standard and Poor's online database; Dow Jones online and Insite. Also included were published articles in other sources; biographies of notable industry people; books on photographic technology; the Wolfman Report on the Photographic Industry(the publication of which ceased in 1984); and industry trends reports published by the Photo Marketing Association.

As emphasized by Eisenhardt (1989), write-ups of each instance of technology selection, or rejection, were completed during data collection. This not only aided cross-case comparisons, but enabled me to write down my immediate and vivid impressions of the field work. The three principles of data collection (Yin 1989) were strictly followed: multiple sources of evidence were used; a case study database was kept separately from the evidence that is cited in the research, and in order to increase the reliability of the information, a chain of evidence was maintained so that an external observer can follow the derivation of any evidence from initial research questions to ultimate case study conclusions.

The data thus collected was arranged in chronological order, when possible plotted on common time scales, and analyzed to infer patterns or consistencies over time to address the research questions guiding us. The differences, as well as similarities, in the attributes of various designs were recorded. The industry dynamics leading to change were traced diligently and inferences made. Finally, organizational strategies adopted by various firms after each technological discontinuity along with other influences on design selection were studied and recorded. Arrays, matrices of categories, and data displays were developed as I gathered data.

Data collection for case studies is notoriously difficult, not least because of our inability to employ research assistants. This is because of the continuous interaction between the theoretical issues being studied, with which an assistant's familiarity can only be limited, and the data being collected. Moreover, data collection procedures are not "routinized", and opportunities and constraints continue to emerge until the very end, sometimes dramatically altering the intended study.

In conducting this research, I discovered first hand what Singleton and Straits (1995: 375) meant when they said, "using available data is a bit like wearing someone else's shoes. They may fit perfectly well. But more likely they will either be too small, pinching your toes, or too large, causing you to stumble. Seldom will available data be ideally suited to the purposes the researcher has in mind." First of all, due to the concentration of the industry - Kodak overwhelmingly dominates this industry, followed by a very distant Fuji - data was hard to find. In contrast, data was easy to find for the fragmented part of the industry, in the case of photofinishing. Consequently, most available data was produced by and aimed at the photofinishing community. Moreover, data on industry failures was extremely hard to find. The press, I found, tends to focus on the future. A product, which does not seem to have a bright and profitable future is not granted much space in the media. Indeed, failure has no parents. Failures are automatically and overwhelmingly attributed to 'bad design' and poor technology and then forgotten.

I relied heavily on field notes throughout this research. Field notes are like a running commentary, recording newly found facts and capturing thoughts as they occur along the way. These were especially helpful since I was working on four different cases at the same time, and it was easy to forget aspects of one while working on another. Also, it provided an excellent perspective on my progress, how my understanding of the industry had evolved and what the misconceptions I shared with several industry people at the outset.

DATA ANALYSIS

Analyzing data is the heart of building theory from case studies, but it is both the most difficult and least codified part of the process (Eisenhardt, 1989). Eisenhardt quotes Miles and Huberman (1984: 16) as arguing, "one cannot ordinarily follow how a researcher got from 3600 pages of field notes to the final conclusions, sprinkled with vivid quotes though they may be." When the research problem is open-ended, or exploratory, as was the case here, the volume of data accumulated can be daunting. Mintzberg and McHugh (1985) examined over 2,500 movies in their study of strategy making at the National Film Board of Canada – and this was only part of their evidence. By the time I decided to end my data collection, the data ran over 6,000 pages. This included articles and figures from all the sources mentioned above. The history of the industry that I wrote for reference exceeded 300 pages and could easily have been longer.

The main objective of this exercise was to reconstruct the history of the industry and thus weave the numerical and textual data into a coherent story. This is an essential step in case study research. For example, Hughes (1983) reconstructed the history of electrification in the United States to argue that the phenomenon could be better understood from a 'system' perspective. Similarly, Latour (1997) established that the failure of the automated rail system in Paris (ARAMIS) was not due to technological reasons, as widely believed, but of the inability of its founders to 'enroll' sufficient support for it. In the technology management literature, Clay Christensen's work is noteworthy for reconstructing the history of the disk drive industry to argue that the failure of firms in this industry was due not to their distance from customers, but to 'too much proximity.'

Drawing upon several exemplary case studies, I started by preparing a case study database. For instance, all the information that I could find about the factors that could have influenced the success of roll-film cameras was collected and then shaped into a case study. Similarly, stories about the disc camera, instant imaging and digital imaging were constructed. Although these individual case studies are not reproduced in the body of the dissertation, I have done my best to cover the most important details from each in the analysis. The analysis started by 'pattern-matching.' This was an attempt to compare an empirically based pattern with an expected one. This process influenced the type of questions I asked: what kind of strategic action is expected right after a discontinuity? What kind of alliances do we expect incumbents/ new entrants to forge? What is the expected sequence in which events occur? Is the technology successful first, or is it adopted first? I ensured that any rival explanations were considered in pattern-matching, and that propositions guided the explanations. As Yin suggests, to explain a phenomenon is to stipulate a set of causal links. In most existing case-studies, explanation-building has occurred in a narrative form. Because such narratives cannot be precise, I tried to make sure that the explanations should reflect some theoretically significant propositions, or extend the theoretical propositions in a meaningful way.

This process was, of course, iterative. It involved starting from the initial theoretical propositions, comparing the findings of the digital imaging case against these, revising the propositions, again revising the proposition, comparing the revision to the facts of the second, third, and fourth case and so on. The data was made meaningful by putting the information into arrays, making matrices of categories and placing the evidence within them, creating data displays – flowcharts and other devices—for examining the data, tabulating the frequency of different events, and putting information in a chronological order. A high quality research design was maintained throughout by ensuring construct validity (use of multiple sources of evidence; establishing a chain of evidence), internal validity (pattern-matching; explanation building), external validity (replication) and reliability (ensuring a case study protocol as suggested by Yin; developing a case study database). However, as in any qualitative, quantitative, or case-based study, a large number of judgements were made throughout the data-collection and analysis phases. The judgements were guided by considerations of detail vs. relevance or comprehensiveness vs. focus. I tried my best to avoid common mistakes such as leaping to conclusions based on limited data (Kahneman & Tversky, 1973), being overly influenced by vividness (Nisbett & Ross, 1980) or by more elite respondents (Miles and Huberman, 1984), ignoring basic statistical properties (Kahneman & Tversky, 1973) and inadvertently dropping disconfirming evidence (Nisbett & Ross, 1980).

The fact that the four cases I studied spanned different periods made the data both overwhelming because of sheer volume and at the same time more manageable because of the division into four parts. Since the data was mostly historical, I tried to ensure that I did not simply reproduce historical conceptions about the success or failure of technologies. Since several secondary sources that I used for data in the first case study presented analysis and conclusions along with data, separating the data from judgements was crucial in using such sources. One way of doing this was by comparing my findings with earlier notions. For instance, while I used Reese Jenkins' (1975) widely cited history of photography[15] as one source of data for the first study, I have reached completely different conclusions regarding the reasons for Kodak's success. Whereas Jenkins attributes much of it to Eastman's development of a system of patents covering both product and process (Jenkins, 1975: 97), I argue that Kodak's aggressive patenting strategy, combined with an equally aggressive tendency to acquire competitors, was only partially responsible for its success. This is in sharp contrast with earlier analyses (Tedlow, 1997), which rely on both Jenkins' data *and* conclusions to support their arguments.

Historical analysis allowed me to beware of cohort and period effects in the data (Glenn, 1977; Singleton, Straits and Straits, 1993). Singleton et al explain cohort and period effects with the following example; consider a cross-sectional survey containing measures of age and alcohol consumption. If we found that alcohol consumption is negatively correlated with age, this could be due to one of two kinds of influences: life course (as people grow older, they drink less) or *cohort* (older generations drink less than younger ones). By the same token, if we found no association between age and alcohol consumption, this does not necessarily mean that alcohol consumption may be due to a third influence of aging – the effects of specific historical periods. As times change, so might the consumption of alcohol. This is called a *period* effect (Singleton et al, 1993).

A cross-sectional analysis of the photographic industry could not have revealed both these effects. For instance, does photographic activity increase or decrease with age, or with increasing ease of use of technology? Or is it that people exhibit difference preferences in different periods (period effect)? Did the market for photography simply expand from 1890s to 1920s? Or, were these two different markets (cohort effects)? It

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[15] Among many others, Tushman and Rosenkopf (1992) and Latour (1995) have relied on this study for historical evidence on technological developments in the photographic industry.

was only possible to make reasonable claims about these phenomena given the longitudinal data available.

Searching for cross-case patterns is a standard technique in case study research (e.g., Eisenhardt and Bourgeois, 1988; Tushman and Rosenkopf, 1992). However, despite the fact that most scholars stress 'replication' in case study research (Eisenhardt, 1989; Yin, 1989), because of the temporal lag and technological differences between the four cases, I did not try to find replication where none existed. Whereas some systematic patterns *were* spotted across the four cases, the real contribution of the study lay in the manner in which each case illustrated particular aspects of the theory that eventually emerged from the analysis.

Finally, I found that my own interest and previous knowledge of photography was both a bonus and a hindrance in this research. It was a bonus because it made it easier for me to understand the technological dynamics of the industry -- especially the technical jargon, and the workings of different cameras, for example.. It was a hindrance because I had predisposed ideas about photography. I had to challenge myself continuously, putting myself in the shoes of a lay person, whose ideas of simplicity, 'good' photography, choice of subjects or locations, or choice of occasion for photography, I sometimes had difficulty conceiving. In order to make sure that I kept my own convictions out of the research, I repeatedly asked several colleagues about their opinions on various things. It was an extremely valuable exercise. For instance, I showed a colleague, who has never used anything other than a completely automatic camera, and cannot even load film confidently, about 40 photographs, and asked him to pick the 'best' one. He picked one that had unrealistically bright colors, poor composition and a subject who was right in the center with half his face in shadow. A professional photographer would *not* have picked that particular shot! His choice was revealing for me and helped me tremendously in realizing my own pre-conceived notions about 'good' and 'bad.' Similarly, I had long debates with several colleagues, about why one should buy digital cameras and what influenced their choice when they went to buy a camera. The same fellow students provided exceptionally useful comments on my 'theories,' which I discussed with them. These 'focus groups' helped me throughout the research and I would encourage future researchers to follow similar practices /routines.

CONCLUSION

This study's findings do not claim to be purely inductive. Indeed, it may be argued that the findings of any exploratory study can never be purely inductive, in this case especially; the research design was clearly informed by theory. For instance, I was aware that previous researchers had found evidence of path dependency in technology evolution. Similarly, I was aware of the pitfalls of overlooking institutional aspects of the evolutionary environment. From recent studies in the sociology of technology, I also gathered that players tried to 'problematize' (Latour, 1987) and build communities or networks around themselves or their technologies. Finally, the importance of efficiency or functionality of technologies in determining their success cannot be downplayed. All these considerations, along with others, mentioned in the theory chapter, were taken into account when charting the course of various technologies. Such an inter-disciplinary perspective yielded several interesting insights, and allowed the study to reconcile the various different perspectives that I borrowed from to begin with, while at the same time contributing to each.

While many of the conclusions in this study are argued analytically, drawing on both empirical data and existing theory, they can at most be treated as tentative propositions because they emanate from a total of four case studies. However, the exploratory nature of the research demanded a few, in-depth case studies. In carrying those out, I have tried to abide by the established protocol for case-study research. By no means does this research explain everything about the evolution of photography. On the contrary, through this study, I have managed only to scratch the surface of what could be a much bigger, more insightful inquiry into technology evolution. The research yielded several questions about the success or failure of various products and technologies within this industry, which have so far eluded the eyes of researchers. More in-depth, exploratory research is needed if greater insights are to be developed. Finally, the operationalization of various important constructs and relationships is encouraged along with survey-type research to validate the findings of this research.

CHAPTER 3: EARLY HISTORY OF PHOTOGRAPHY AND DRY PLATE TECHNOLOGY[16]

This chapter presents a brief history of the photographic industry and investigates on the three main designs preceding the roll-film camera which dominated the industry.,. These designs included the daguerreotype, those based on wet-collodion technology and those based on dry plate technology. The objective of presenting the early history of the industry is to familiarize the reader with the context in which technological changes occurred and the sequence of events, which led up to the roll- film camera. The section on dry plate technology is especially important, and hence discussed in greater detail, since it was with dry plates that much of the meaning that is attributed to photography evolved.

DOMINANT DESIGNS IN PHOTOGRAPHY (1839-1900)

I. The Daguerreotype.

The combination of two distinct scientific processes gave rise to photography. While these processes were known for quite some time, the technology, which served as the basis for photography, took hundreds of years to actually come into being. The first of these processes was optical whereby light was used to produce images of objects on surfaces. The second process was chemical. For hundreds of years before photography was invented, people had been aware that some colors are bleached in the sun, but they had made little distinction between the catalysts: heat, air and light. By the beginning of the nineteenth century, several individuals were conducting experiments to make images captured by projecting light on chemically coated surfaces, permanent. The first

[16] For details of the institutional field and technological evolution prior to roll-film technology, I have relied heavily on data provided by Jenkins (1975).

successful picture was produced in June/July 1827 by Niépce, using material that hardened on exposure to light (Leggat, 1996). This picture required an exposure of eight hours. From 1827 to 1839 several designs competed for recognition, the leading contenders being Fox Talbot, an English inventor, and Daguerre, a Frenchman and Niepce's business partner. By 1839, with help from the French government, Daguerre's technique had been established as the dominant design. The process was named Daguerreotype, and it proceeded as follows. Silvered copper sheets were sensitized with iodine vapors just prior to exposure in a camera. The plates were exposed to a sharply focused optical image in the camera and then treated with mercury vapors in order to develop the latent image created by exposure. Finally the image was "fixed" in a bath of sodium thiosulfate.

Almost instantaneously, an entire market developed around Daguerreotypes, with several firms becoming involved in the production of silvered copper plates (which now came in rolls), cases, mats, preservers, and so on. At the same time, various methods for ensuring a fine surface on the plates had sprung up/emerged. In the parallel camera business, cameras and Petzval portrait lenses produced by Voigtlander established the standard for the industry (Jenkins, 1975: 28). Similarly, a competition ensued for successful designs - often protected by patents - in other Daguerreotype apparatuses such as camera boxes and camera stands, chemical boxes, baths, and headrests. However, in most cases, there were multiple designs that co-existed instead of a single one becoming the standard.

It is important to note that Daguerre's design was not unchallenged. Different than, and rival to, the Daguerreotype was the Calotype invented by William Henry Fox Talbot. Talbot's paper to the Royal Society of London, dated 31 January 1839, actually precedes the paper by Daguerre. Talbot's design, called a Calotype was somewhat inferior in quality but it allowed the development of several positives. Essentially, a piece of paper was brushed with weak salt solution, dried, then brushed with a weak silver nitrate solution, dried again, making silver chloride in the paper. This made it sensitive to light, and the paper was now ready for exposure. This might take half an hour, producing a print-out image. It was fixed in strong salt solution - potassium iodide of hypo. Since Talbot's photography was on paper, inevitably the imperfections of the paper were printed alongside with the image, when a positive was made. Several people experimented with glass as a basis for negatives, but the problem was making the silver solution stick to the shiny surface of the glass.

Today's photography is based on the same principle, whereas by comparison the Daguerreotype, for all its quality, was a blind alley. However, despite its advantages, the Calotype process was not as popular as the Daguerreotype. Following the success of the Daguerreotype, improvements and modifications in optics and camera equipment came almost at once as an adaptive response to the special conditions of 'daguerreotypy.' Since the Daguerreotype produced a direct positive, the image produced was the reverse of the original. Soon opticians introduced reversing prisms or mirrors to re-invert the Daguerreotype image. For portraiture, often conducted in the several portrait studios that had opened up everywhere, reducing the exposure time was a primary goal. One method was to increase the light-gathering ability of the lens. For this a concave mirror replaced the lens, thereby increasing the light-gathering power and eliminating reversal of the image for direct positives. The Petzval lens was based on this principle. Finally, several methods were introduced for improving the surface of the silvered plate, culminating in the adoption of electroplating and the tinting and coloring of Daguerreotypes (Jenkins, 1975).

II. The Wet Collodion Process.

By the 1850s a new process for capturing images was emerging. This process was called 'wet-collodion' and it consisted of using collodion, a thick and syrupy liquid, widely used by surgeons as a liquid bandage owing to its strength and adhesion, to hold light-sensitive salts to glass plates. Once the salts, such as potassium iodide, were in the mixture of collodion, the viscous liquid was poured onto the plate. A thin film containing the necessary iodides was left on the plate allowing the alcohol and ether to evaporate. Ready for sensitizing, the plate was placed in a bath of silver nitrate. This formed a light sensitive compound of silver iodide on the surface of the plate. Once sensitized, the plate was exposed in the camera before the collodion began to set and dry. After exposure in the camera, the plate was quickly returned to the darkroom. Using an acidic solution of ferrous sulfate, the plate was developed, then rinsed and fixed in a mild solution of potassium cyanide, or hypo.

The wet plate photographers could now produce multiple images from a single glass plate by projecting the image on paper. Another possibility was a collodion positive such as the Ambrotype or Tintype. The Ambrotype was simply an underexposed glass plate negative. When placed against a dark background, it appeared as a positive image. Conversely, in the Tintype a thin piece of black enameled iron was used in place of glass. The Tintype went on to become 19th-Century America's favorite quick picture. This style of photography endured along with the wet-collodion on glass process for close to fifty years because it was much cheaper than any other form of photography.

The technological change from Daguerreotype to collodion processes created new manufacturing sectors and technological trajectories. In order to execute this new collodion process, the photographer needed, in addition to his traditional camera and lens, glass plates, collodion, halide salts, silver nitrate, such developers as protosalts of iron or gallic or pyrogallic acids, hypo, special photographic papers, varnishes, bath pans, and ancillary chemical apparatus. Soon, organizations sprung up specializing in the production of all the necessities. In parallel with these advances, camera technology became more complex. Cameras now included several parts other than a lens. While two important developments in lenses were the Globe lens, a relatively inexpensive lens of high quality, and a new landscape lens called the Aplanat,a dominant design in landscape photography, cameras with panoramic features and fast shutters were also introduced. A principal challenge before lensmakers was how to enable the lens to gather light which eventually led to larger lenses. Around the same time, stereo cameras were introduced (producing 3-D images) , but they were met with only limited success. The advent of the wet-collodion process initiated the photographic paper sector of the industry.

III. Gelatin Dry Plates.

The development of the collodion process marked a watershed in the development of photography. However, this wet-plate process had limitations, one being that it was necessary to keep the collodion moist. For a number of years several attempts were made to discover ways of keeping the collodion moist for long periods. The materials tried included unusual ones like licorice, beer and even raspberry syrup. Some success was achieved by using a mixture of bromide in collodion. The ideal binder would be one which enabled the plates to be used only when dry. It was not until 1871 that the next breakthrough was achieved by Dr. Richard Leach Maddox, when he began using gelatin. In fact, as far back as 1850 Robert Bingham had suggested the use of gelatin, but this idea had not been taken up at the time, presumably because of the announcement of the collodion process the following year.

Gelatin is a protein obtained from animals, which is transparent and odorless, and used in a number of food processes. The first account of its use in photography is in the British Journal of Photography for 8 September 1871, when Maddox suggested that the sensitizing chemicals could be coated on to a glass plate in a gelatin rather than a collodion emulsion. Maddox's process, though revolutionary, was far slower than collodion. Several manufacturers experimented with it, the most successful being Charles Bennett, who in 1878 announced a new gelatin dry plate process. This was a major breakthrough, particularly since Bennett's process also considerably enhanced the sensitivity of the emulsion, reducing the exposure time to one tenth of that required for the collodion one.

This dry process was revolutionary because it meant plates could be pre-sensitized. Photographers were finally relieved of the need to carry about their own darkroom and chemicals. The gelatin-on-glass process set in motion fundamental product, production, marketing, and organizational changes that affected the entire industry. With this, several new firms emerged including The Eastman Company, which began mass production of dry plates.

Similarly, a new range of cameras began to appear. Cameras now came with magazines which could hold several dry plates, and shutter speed became the focal point because of the highly sensitive nature of gelatin. Because the photographer had to exercise considerably greater caution in using the new photosensitive materials, darkroom lanterns were introduced and camera boxes were made increasingly light-tight. During the 1880s, various types of between-the-lens and focal plane shutters were developed, along with the blade and rotary shutters, and self-setting shutters. Also, the increased sensitivity of the photosensitive material lessened the importance of lenses of great light-gathering power in the new cameras. Below, I describe the institutional context in which dry plate photography took hold.

LATE 19TH CENTURY INSTITUTIONAL CONTEXT

In this section, I describe how the regulative, normative and cognitive aspects of the institutional field that emerged hand-in-hand with dry-plate technology.

Emergence of a Field Around Dry Plate Technology

The gelatin-on-glass process set in motion fundamental product, production, marketing, and organizational changes that affected the entire industry. Several new firms sprang up including *The Eastman & Strong Company* (later the Eastman Company, and subsequently the Eastman Kodak Company) which began mass production of dry plates. While the initial technological advances in this direction had largely been made in Britain, the two dominant American jobbing houses, Anthony and Scovill, who later merged, soon adopted the new technology. Anthony imported plates from Britain while Scovill imported them from Holland. Both attempted manufacturing them but failed to meet the standards and prices of imported and even domestically produced plates, so they reverted to their traditional strategy of acting as jobbing agents for other more competitive manufacturers. Among the most important of these were Carbutt of Philadelphia, Cramer and Norden of St. Louis, and Eastman and Strong of Rochester. Apart from these, the field consisted of various suppliers of chemicals, glass, and other parts for cameras such as lenses.

The transition from the wet-collodion process to the dry plate process changed the configuration of the photographic organizational field. With the wet-collodion process, the photographer had to be adept at emulsion-making, which was used to cover wet-plates. Immediately after exposure, the plates were again coated with a chemical to let the image develop. Photography required a considerable knowledge of when to apply what chemical, and for how long. Photographers had to buy chemicals, plates, cameras and arrange for darkrooms in order to conduct photography. Naturally, professional photographers and some serious amateurs mainly dominated the field. The only centralized activity in the industry was the distribution of photographic suppliers. Thus, the biggest, most important firms in photography were the marketers of photographic equipment from stores and "depots."

Dry plates did not require photographers to possess a knowledge of 'emulsion-making' or to buy chemicals to capture an image. Moreover, with dry plate photography, plates, coated with emulsion, could be stored both before and after exposure. This meant that these plates could be centrally manufactured and scale economies captured. Thus, the introduction of gelatin plates quickly shifted the preparation of photosensitive materials from the decentralized hands of photographers to centralized manufacturers, who produced for a national market consisting largely of local professional photographers. This was enabled by mass production technology, which was making inroads into the American economy.

In the dry-plate era, the manufacturer became the "channel captain" of the industry – the key player in the value chain replacing the distributor in that role. As the market expanded for dry plates, manufacturers proceeded to grow downstream, creating room for new, innovative firms to enter and restructure the industry. Several manufacturers now had their own marketing departments which worked directly with supply houses and professional photographers. Accordingly, the once powerful position of the national jobbing houses began to decline further. Still, the concentration of production knowledge from the wet-collodion plate era was significant, creating a field much more conducive to normative isomorphism.

Also, the emphasis shifted away from the highly specialized knowledge of chemistry, which was required of photographers. Since the production of plates was now concentrated in the hands of the manufacturer, information about chemistry became concentrated too. Technical communication about emulsion-making and plate manufacture almost disappeared from public sources. Although technical journals, societies and conventions continued to play a role in the circle of professional photographers, patents on new products, complex methods of production, expensive production machinery, and trade secrets all erected barriers against the diffusion of manufacturing information, leaving employee mobility and company acquisition the principal channels of diffusion.

Eastman had joined the field around the time when the industry was shifting from wet-collodion to dry plates. Too much of a novice to be committed to the old wet-collodion technology that required highly specialized knowledge, Eastman avidly pursued the new developments in gelatin emulsions as reported in the English journals and soon initiated limited production of gelatin plates. He was the first one to introduce mass production technology in this industry. He developed and quickly patented machinery for coating of plates, thereby gaining the economies of large-scale production. He also patented his machinery in Europe, hoping to gain an advantage over other American plate manufacturers and to sell either licensing rights or the patents themselves in Europe in order to provide capital for his manufacturing venture in the U.S. At the time, the major portion of the nation's dry plate production was concentrated in the hands of three companies, Eastman, Cramer and Carbutt, leaving only local markets for many urban producers across the country who had initially found the barriers to entry quite low.

The introduction of dry plate technology, combined with several social trends resulted in a new institutional field, which rested on regulatory, normative and cognitive pillars (Scott, 1995). Below, I discuss how these institutional pillars were constructed as technology continued to evolve.

Regulatory, Normative and Cognitive Developments

[The parallel development of technology and regulatory/ normative/ cognitive institutions is summarized in Table 3.1].

Table 3.1: Regulative, Normative and Cognitive Developments.

1871-1892: Parallel to Evolution of Dry-Plate Photography

Technology	Regulatory Changes	Normative Changes	Cognitive Changes
-1871: dry plate technology was	• Manufacturing of dry plates led to consolidation	• With dry plates, it was no	The subjects of initial

introduced - with increasing mobility, smaller cameras, with magazines were introduced. - as a market developed for photographs, the penetration of dry-plate cameras increased manifold. - EKC's introduction of mass production shifted the emphasis to process, encouraging more innovations in manufacturing technology. - The greater sensitivity of dry plates led to innovations in shutter-technology in cameras.	with dry plate manufacturers dominating the industry. • The photographer's task became more limited (no more emulsion-preparation), and individual knowledge was subsumed within large organizations. • EKC developed a competitive advantage through its patents on plate-making machinery. • The industry segment dealing with knowledge of emulsion-making disappeared. • The decline of specialized knowledge led to lower barriers to entry, as a result several new firms entered the industry. • As a result, Kodak and other incumbents engaged in price-fixing, driving smaller firms out of business. • Anti-trust laws (Sherman Act, 1890) were passed to curb price-fixing and collusion. • Since dry plates acted as a negative too, enabling the manufacture of several copies of an image, a new industry was born around the photograph (postcards, prints etc.).	longer the norm for photographers to have an elaborate knowledge of emulsion-making. • Increasing mobility and WWI encouraged smaller, lighter cameras and choice of exotic, far-away lands (or battlefields) as subjects. • As a result, research and development was focused towards the manufacture of smaller cameras. • Since photography carved out a space for itself by emphasizing its ability to capture images more accurately than painting, quality became established as the primary criterion for 'good' photography.	photographs were important people, who struck poses accordingly. This tendency was institutionalized for decades, even when photography was within reach of the "common" man / amateur.

Regulatory Institutions:

Dry plate technology led to consolidation in the photography field. Although most metropolitan areas of the country witnessed the entry of many small dry plate manufacturers in the early 1880s, St. Louis and Rochester emerged during the next two decades as the principal plate production centers of the Western Hemisphere with three firms, mentioned above manufacturing the majority of the dry plates in the American market. Simply due to their early entry into the industry they had secured access to the market through their sole-distributor relationships with the leading jobbers. The large profit margins in plate production attracted many manufacturers in the early 1880s; however, most of them stayed in business only until their invested capital had been consumed.

We must remember that this was a period when the trend of inventions by individuals was giving way to innovations by corporations. Individual talent was being absorbed by companies who were beginning to engage in mass production of more complex products and technologies, casting their nets over previously inaccessible markets. Such corporations maintained their hold on markets by continuously buying out new technologies, which could pose a threat to their dominance and spruced up their power in individual regions by weeding out small, local competitors. The regulatory institutions necessary to maintain a competitive environment were struggling to keep up with novel corporate strategies, which commonly included price fixing and collusion. Numerous businesses sought relief from price competition through pooling agreements and trade associations, but since such agreements were not enforceable in courts under earlier common law precedent, they proved to be only temporary measures (Jenkins, 1975: 175). For instance, when the economy experienced a short economic recession in 1884-85, which resulted in change of marketing relationships prevalent in the organizational field, a number of leading dry plate makers established the Dry Plate Manufacturers Association which had Eastman, Cramer, Norden and Walker-Reid-Inglis as notable members. The purpose of the meeting was to establish a scale of prices for plates, a measure intended to inhibit price-cutting as an increasing number of competitors entered the field. Several meetings were held, and the association continued for another two to three years. In the late 1880s, as the leaders of the industry came to accept and advocate administered prices on plates and as economic prosperity returned, prices stabilized and the formal association disappeared.

As the American government began intervening to stop collusion, the formation of holding companies and trusts, outright acquisitions of smaller companies and patenting became the new favored strategies. Eastman's competitive methods, and indeed his basic business philosophy, were no different. He did his best to patent everything he could and went to great lengths to buy the patents of others. He entered into pools to control price and output. He began buying other companies, at least 16 of them, in a matter of few years, to control competition.

Perhaps the most noticeable case in that time period which prompted government intervention and a fundamental change in regulatory institutional environment was that of Standard Oil Company which had organized a trust in 1879. Legally, trusts were an old device to separate ownership from control, used chiefly in the interest of minors and widows. The effectiveness of the application of this legal device to the organization of industrial enterprises by the Standard Oil Company created increasingly unfavorable public reactions during the 1880s and culminated in the passage of antitrust legislation by many states in the late eighties and early nineties, and in the passage by Congress in 1890 of the Sherman Act, a federal antitrust law. Nevertheless, in the late 1880s, when the trust form of organization was under its greatest attack, the state of New Jersey, in pursuit of its long-standing policy of attracting corporate business, revised its general laws to permit a chartered Company to hold stock in another corporation. This modification of New Jersey incorporation law opened a new alternative to business firms either anticipating consolidation or already under attack as trusts. As other states gradually relaxed the restrictions that limited the size and privileges of corporations, industrialists and financiers promoted consolidations in the belief that they were immune from the federal antitrust prohibitions.

The regulatory environment was changing fast with the corporate revolution. As a result, during the 1880s and 90s, regulatory institutions were ambiguous. Indeed, the normative practices and regulatory institutions were often at significant odds with each other. An exasperated Eastman once said that he did not understand the antitrust laws and did not know anyone who did (Jenkins, 1975). Whether Eastman understood these laws or not, it is doubtful if he did not realize that it was the particular nature of the dry-plate technology - enabling mass production, factory-readiness, and wider appeal because of its portability- which led to horizontal integration. This process/phenomenon exposed photographic companies to this particular side of the law. Similarly, by preventing price fixing and monopolies which were common normative practices at the time, the Sherman Act drove Eastman and other firms, such as DuPont, away from agreements with direct competitors and toward vertical integration. For the story of this development at DuPont, see Chandler and Salsbury, 1971). Also, firms in the photography trade could no longer hope to fix prices and sustain their existence as easily as in the past. While patents were becoming increasingly vulnerable, the ones held by smaller firms could at least be bought. This was what a number of firms did. More acquisitions were witnessed at this time than ever before (Jenkins, 1975).

Thus mass production technology prompted changes in regulatory institutions. This was followed by the evolution of normative institutions synchronizing with the new regulatory environment, particularly as Kodak and other players gradually ceased to fix prices and collude, and began pursuing other strategies. The result was the emergence of a new configuration in the organizational field.

Normative Institutions:

The institutional field in the 1870s and 80s was centered around a particular technology which embodied the current beliefs about the activity of photography, in other words, what it was, should be, and how it could and should be practiced. Two tendencies, institutionalized within the field, and driving organizational action were especially salient: a focus on improving quality, driven by the institutionalized understanding of photography in terms of accurate representation of objects; and, a drive to produce smaller, more compatible cameras, driven by the mobility that dry-plate cameras afforded. Both quality and compactness were taken for granted as key objectives of any technological development effort within organizations. These two institutional understandings were a result of both technological and social developments. Below, I discuss each one of these separately:

Smaller, more compact cameras: The greater mobility offered by dry-plate techniques encouraged more photographers, whether working on their own or for newspapers., to travel long distances to sites of interesting and newsworthy events and send back pictures. Indeed, the organizational field was no longer limited to plate-makers, camera manufacturers, paper manufacturers distributors and professional photographers anymore. The photograph was also a product, and as such, it required channels of distribution. Through the printing press, photographs were channeled into homes. Publishers multiplied to cope with the demand; as production increased they had to set or follow the public taste and find the right forms of presentation.

At the same time, the space in which photography was practiced also expanded, driven by increased travel and, interestingly, the American Civil War (1861-65). The American Civil War profoundly influenced the existing composition of most photographs. For the first time, a photographic record was made of the carnage and futility of war. From then on, the camera became the privileged witness of events. Governments stepped in and sought to use it for propaganda purposes. The press gave more and more space to illustration, whetting the curiosity of its readers, who were made more alive to international events, to overshadowing realities beyond the narrow round of daily life. To attract a wider readership, newsmen sought out the strange and unusual. Out of this trend arose the "reportage" – a form of.... Later on, when smaller, lighter cameras and the introduction of camera film made it possible, photo reporters were to be found wherever something was happening, building up the archives of modern history.

The Civil War, however, was only one of the many spectacles that was brought into homes through photography. By steadily enlarging the field of knowledge and awareness, photography directly modified the traditional value of human experience. Until now people had lived narrow lives, knowing nothing of the world beyond the bounds of local experience and personal relationships. The civilization of the image began with the multiplication of photographs, and it emphasized visual knowledge in contradistinction to physical experience. Henceforth people saw more and more of what they would never actually experience – with momentous consequences, inasmuch as photography is but one code among others, reducing everything to the same scale, and limited to the delineation of appearances.

The field of vision opened up by photographers widened. After illustrating the immediate life around them in Europe and the East Coast of the United States, they began ranging into distant countries, bringing back uncommon/distinctly different and "exotic" pictures. It was the heyday of colonial expansion and they followed the colonizers, recording what they saw in Africa, in the East, on the American frontier -- not only the landscapes but also the people, the natives, their homes, dress, way of life. The unexpected consequence was that, by their strangeness, these visual records of foreign places began undermining the assumptions by which Western man/civilization lived – undermining them, then showing them up.

Photographs were products whose consumption was greatly increased by the emergence of the museum which removed material culture from their original setting and function and brought them together for comparative purposes. Common museum exhibitions were ones at which people could look at photographs of war, people from primitive tribes or simply different cultures - usually photographed in their traditional costumes or enacting their indigenous rituals and rites - photographs of local or international celebrities, various political leaders and so on. Magazines increased their sales manifold because of the new pictorial content and postcards became an ever more popular outlet for the consumption of photographs.

While it became possible for American households to consume photographs of celebrities, politicians, far-off places and the like, it was not common to see photographs of ordinary people. Given the expense and effort involved in taking a picture, few could afford to have family pictures taken by professionals, although the number was increasing. Studios were frequented mostly by the wealthy, who would have their portraits framed or printed on carte-de-visites, a popular 19th century phenomenon. Despite numerous advances in the simplification of cameras and reduction in their sizes, almost all photos were either taken by professionals or very serious amateurs who pursued this practice as a hobby.

With all these changes coming about as a result of the greater mobility offered by dry-plate technology, the focus of the organizations turned to producing smaller cameras. It is important to note that contrary to the popular belief that smaller cameras were introduced by Eastman Kodak to appeal to the lay person, a drive towards smaller sized and simple to operate cameras was already underway in the field. Since 1881, E.& H.T. Anthony had begun a promotional campaign with the slogan "Dry Plate Photography for the Millions"(Jenkins, 1975). Advertising included recent improvements along with new methods such as rapid action bromide dry plates "for the student, tourist or anyone."(Jenkins, 1975) And Anthony was not alone in peddling photography to the millions. Scovill Manufacturing Company introduced their line of quick-action dry plate cameras at about the same time. Anthony's Equipment #1 (is this the proper name of the equipments?), the least expensive also known as the "Ten dollar equipment" was awarded the Medal of Superiority at the 1881 American Institute Fair in NYC, which Anthony used to his advantage in promotions. Following this amateur equipment promotion, the Anthony Company published in 1882 its first instruction book for the novice, entitled *The Amateur Photographer* or *Practical Instructions in the Art of Dry Plate Photography for Young and Old* (Marder, 1982). This small 54 page booklet was one of the most extensive of its kind and symbolized photography's transformation from a specialized activity for professionals to a slightly less complex one, which could appeal to non-professionals.

A Focus on Quality: While a technological advancement, production of dry-plates shaped part of the future trajectory for photographic equipment, the social process of defining what photography was supposed to be culminated in an overarching focus on quality. During the wet-plate era, the extremely specialized nature of emulsion-making made technically-oriented individuals dominate their respective firms as well as the business. With the important exception of Eastman, all the major companies were founded by professional photographers. Emulsion-making remained an empirical art, and it was mechanically or chemically oriented persons with a background in photography and practical photographic chemistry who were attracted to positions of technical responsibility. The employment in the industry of the college-educated chemist or engineer was still the exception. While the focus on mass production technology shifted the emphasis somewhat from the art of emulsion making, the culture due to the domination of professionals continued. An important aspect of this culture was the focus on quality. Professional photographers have been known less for the 'artistic' quality of their photos and more for the technical quality (accurate representation of the object). This still held true, although the onus had shifted from the photographer to the manufacturer for preparing emulsions that produced high quality images.

Image quality was a key source of legitimacy in the present organizational field. Those concerned about image quality included consumers (professionals and serious amateurs) were quality-conscious and firms engaged directly or indirectly in the manufacturing and selling of an institutionalized technology which was becoming more portable and simple to use everyday. While professionals and serious amateurs obviously valued image quality, the ultimate consumers of images (ordinary people) also seemed to value it; they did not want to buy or consume images of inferior quality. The suppliers of images realized this. A good photograph was defined as one which was as close to reality as possible. This was of course only one way of judging a photograph, albeit one that was the most legitimate one at the time. It was also assumed that photographs met a particular need: preserving a likeness of a person, place, or monument that was important (which object was important enough to be photographed was of course determined by social standards).

The expectation of good quality or accurate representation had been institutionalized over several years. The process of institutionalization of 'quality' could be traced right back to the invention of the Daguerreotype which caused considerable concern to many artists, who saw their means of livelihood coming to an end. Delaroche is credited with claiming that painting was now dead, whilst Johnson reports that Sir William Ross declared that photography spelled the end of future miniature painting (Johnson, 1999). A further blow to miniature portraiture came when the Carte-de-Visite craze began to develop. Indeed, by 1857 art journals was reporting that portrait photography was becoming a public nuisance, with photographers touting for custom portraits. Photography had become a matter for Police interference both on the grounds of propriety and public comfort, many wrote (Zimmerman, 1995).

Zimmerman (1995) suggests that criticism was mainly directed at the increasing encroachment of photography onto the turf claimed by artists or portrait painters. In arenas such as science where accurate representation was deemed essential, there wasn't much resistance. Thus, Charles Baudelaire, whilst reviewing a photographic exhibition in 1859, stated:

> If photography is allowed to supplement art in some of its functions, it will soon have supplanted or corrupted it altogether....its true duty..is to be the servant of the sciences and arts – and to be a very humble servant, like printing or shorthand, which have neither created nor supplemented literature.... Let it rescue from oblivion those tumbling ruins, those books, prints and manuscripts which time is devouring, precious things whose form is dissolving and which demand a place in the archives of our memory - it will be thanked and applauded. But if it is allowed to encroach upon the domain of the... imaginary, upon anything whose value depends solely upon the addition of something of a man's soul, then it will be so much the worse for us. (Baudelaire cited in Zimmerman, 1995)

Some painters dubbed the new invention "the foe-to-graphic art." Certainly those artists who specialised in miniature portraits suffered; in 1810 over 200 miniatures were exhibited at the Royal Academy; this rose to 300 in 1830, but thirty years later only sixty-four were exhibited, and in 1870 only thirty-three (Zimmerman, 1995).

A number of artists, seeing the writing on the wall, turned to photography for their livelihood, whilst others cashed in on the fact that the images were in monochrome, and began coloring them in. Baudelaire's assertion that photography had become "the refuge of failed painters with too little talent" was rather unfair, but it is true that a number of painters turned to this new medium for their livelihood. By 1860 Claudet was able to claim that miniature portraits were no longer painted without the assistance of photography (Zimmerman, 1995). It should be noted however, that absolute likeness was not always what the sitter wanted. Indeed, photographers could not flatter their subjects as artists did.

In 1865 Claudet, by then a respected photographer, came to the defense of photography, following a blistering article in a French journal:

> One cannot but acknowledge that there are arts which are on their way out and that it is photography which has given them the death-blow!

> Why are there no longer any miniaturists? For the very simple reason that those who want miniatures find that photography does the job better and instead of portraits more or less accurate where form and expression are concerned, it gives perfectly exact resemblance that at least please the heart and satisfy the memory. (cited in Zimmerman, 1995)

The ability to depict objects or subjects accurately provided photography with the legitimate foundation on which it could develop. While initial uses were scientific or portraiture, with dry plate technology, photography became even more ubiquitous. As already discussed above, through the printing press, photographs were channeled into homes. Realist discourses in photography had been circulating since Talbot's and Daguerre's announcements in 1839. In its appropriation to relay news of events in the Crimean and American Civil Wars, as well as in the production of scientific knowledge, photographic representation had been imbued with the discursive power to disburse "truth." This elevation to the status of 'fact' filtered through popular photographic discourse to produce the camera as the 'impartial historian;' to produce images as evidence of 'real' life (Johnson, 1999).

Cognitive Institutions

Despite the seemingly clear-cut benefits of photography propagated by manufacturers in the field, the adoption of this practice was mediated heavily by the social context in which it was introduced. Within the realm of users, a particular understanding of photography dominated which provided the basis for who could adopt the practice, and how would it be conducted (who would be photographed and when). Whereas, on the face of it, photographic technology was available to anyone who could operate it, and could be used to capture any image that an individual deemed fit, there was a remarkable regularity in who actually adopted it and the objects which were photographed. For instance, photographs were mostly taken in studios with much deliberation. Mothers would dress up their kids in their best clothes and subjects, without being asked, would strike a solemn pose. As the practice was introduced to the masses, naturally, the implicit code dictating the various aspects of its practice was also conveyed.

The decision to use photography was not as personal as it was deemed to be by manufacturers. Indeed, deep-seated understandings of right and wrong, and propriety that prevailed in society , relating to social status, gender relations, and family values profoundly influenced the practice. Photography, just like so many other 'technical' activities was not for women, or at least 'ladies.' Similarly, photographs were to be taken only of 'important' people or 'important' events. Photography also symbolized modernity, since most of the 'old money' still liked to get their portraits painted. Just as it had been with painted portraits, the rich employed photographers to take their photographs and were beginning to cover walls with photographs of ancestors in displays of pedigree. The photograph was a product that was within reach of many, but the practice of photography was still considered a specialized field rather like surgery.

The following table summarizes the above discussion on emergence of regulative, normative and cognitive institutions.

Table 3.2: The Institutional Pillars Supporting Dry Plate Technology

Type of Institution	Dynamics	Comments
Regulative	• Mass production technology led to the centralization and consolidation of the industry. The regulatory environment was not equipped to deal with the new anti-competitive issues that arose, and a few firms came to dominate the industry. Finally, it was found necessary to introduce legislation restricting price-fixing and pooling. This, in turn, shaped the technology's evolutionary path.	
Normative	• Due to the increased mobility afforded by dry plate technology, photographs became a widely consumed product and proliferated the environment. Photographs were usually taken either of strange and unusual events and objects, or of celebrities, and thus were valued for their information content. • Women photographers were unheard of. It was not their 'place' to get involved in the	• Due to dry-plate technology, it was possible for more people to travel with cameras. The availability of railroads encouraged more travel, and led to smaller cameras. • The relative simplicity of the dry plate technique

	practice which was still quite technical. • It was a norm to preserve family history by having each generation photographed in studios. • Photographs were meant to capture images as accurately as possible.	established simplicity as a prerequisite for photographic techniques. • The 'quality' of a photograph was considered a function of the quality of the dry-plate, a marked shift from the days when all credit went to the professional photographer. • The practice of photography was still actively compared to painting. • Organization-level conceptions of the 'market' for photography were already changing to include the masses. However, it was still firmly believed that consumers expected 'high-quality' photos.
Cognitive	• Under dry plate technology, emulsion making was half-technique half art leading to the domination of professional photographers and chemists in firms, contributing to the institutionalization of quality as the "raison d'être" of photography. • The ordinary consumer was concerned with the consumption of the photograph, not the process through which it was produced (for most people, taking a photo was akin to doing your own surgery).	• The highly specialized emulsion-making technology led to the pre-eminent position in all firms of professionals, deeply immersed in the 'culture' of photography, valuing 'quality,' and 'accuracy.' This arrangement also allowed Eastman to become a source of institutional change. He escaped isomorphic influences to some extent because of his lack of legitimate credentials. He was the only major player without a professional photography background.

CONCLUSION

This chapter illustrates how technologies are held in place not only by physical investments or infrastructure, but also by the meaning systems that evolve around them. Existing institutions, especially those that are relevant to the new development - like painting was to photography - play a crucial role in constructing such meaning systems. This process of construction is carried out by various stakeholders - users, promoters, manufacturers - whose interest then becomes vested in perpetuating these systems. For instance, during its gradual evolution, photography derived its meaning from comparisons with a much more institutionalized practice: painting. Indeed, artists were quite active in defining photography as a means of representing objects accurately, usually in connection with scientific, operational or archival endeavors. Such a definition partially laid the foundation for subsequent technological development, namely a focus on quality.

The increase in travel introduced another consideration, which was to prove important in the evolution of photography: the need for smaller, more compact cameras. Thus, the parameters within which technology was to be developed and advanced were being laid down through a process which involved social developments, existing institutions as well as discursive efforts from various stakeholders. A crucial outcome of the process was the change in popular understanding of photography. The once alchemy-like activity had already begun its descent to the level of non-professionals. However, it was only with the introduction of the mobility consideration that certain limitations of the existing technology were 'discovered.' Before that, the bulk and complexity of the photographic equipment largely went unchallenged. However, the striking thing was that despite this new consideration, a deep immersion into the 'culture' created around dry-plate photography constrained the players' ability to look for technological solutions beyond the incumbent technology (until that is, Eastman bet on the roll film technology, which was available to anyone at the time). Players' own competencies were embodied by dry-plate technology and roll-film technology was not a feasible option. Thus, while the new considerations were heeded, all efforts were made to develop new products within the confines of existing technology.

As mentioned before, the purpose of this chapter was to familiarize the reader with the peculiarities of the institutional context in which photographic technology was evolving before Eastman introduced its roll-film cameras. At the same time, however, the chapter also serves to illustrate the social nature of technological change and identifies some patterns that are repeated in subsequent chapters. The subsequent chapter discusses the roll-film camera, which was the next and longest-lasting dominant design in the history of the industry.

CHAPTER 4: THE EVOLUTION OF ROLL FILM TECHNOLOGY

The roll-film camera, introduced in 1882 by Kodak, can be considered the fourth dominant design in the history of the photographic industry, after the Daguerreotype, the wet plate and dry plate. The basic change from the previous dry-plate-based design was the following: the glass plate on which the image was used to form was substituted by a paper, and later on a celluloid film, which could be rolled. The increasingly mobile photographer was suddenly free of the enormous burden that glass-plates presented. Instead of lugging stacks of heavy plates with him, the photographer could capture images on the paper film, and then develop them later in a darkroom. Unprecedented success followed. After all, a major 'need' long unfulfilled had been met. Roll-film technology put the "common" person behind the camera creating a new breed of photographers. Its simplicity enabled even the most technologically challenged person to enjoy the pleasures of photography. As cameras became simpler, better and cheaper, their popularity increased to what we see today, where almost every American household owns a camera.

As appealing as these arguments may be, they represent some fundamental misconceptions about roll-film technology's success. Far from being successful at its introduction, roll-film technology was actually considered a *failure* by all, including Eastman Kodak. Moreover, contrary to popular belief, the technology was *not* new, and had been around for a while. How roll-film technology rose from a failure to an unprecedented success is a spectacular case study in technology evolution, as well as for the study of the creation of a new institutional field. This particular case provides important insights into the complex process of technology evolution and promises to contribute substantially to several areas: the question of the inherent superiority of technology; the source for the impetus for change in institutional fields; whether the 'emergence' of dominance as a result of a sequence of random events falling in line or something more systematic; and whether new fields arise around technologies or issues.

First, I describe the issues that arose following the introduction of this technology, and discuss how Eastman Kodak tackled them amidst a rapidly changing institutional context. Several changes that occurred during period 1880-1920, including increased travel, greater mobility, the rise of amateurism, changing gender roles, redefinition of the family provided a new context in which photography could conceivably be re-defined. The original roll-film technology was transformed to the extent that it came to embody the new beliefs, interests and understandings that formed the new institutional context. Later in this chapter, I discuss insights that this case provides.

THE INTRODUCTION OF ROLL FILM CAMERA

Roll-Film Technology

Towards the end of the 19th century, greater mobility offered by railroads and increased travel pushed technological development in the photographic field towards smaller, simple-to-operate cameras. Several small inventors were busy producing cameras which catered to the changing institutional environment. These included William Walker, who jointly holds the first patent in roll-film cameras with Eastman himself, and who was at the time engaged in the design and production of a nationally distributed pocket camera for the serious-amateur market. His cameras were one of the smallest available and he advertised them as "Walker's Pocket Cameras for Everybody." In a manner typical of the period, Eastman appropriated Walker's talents for his own organization. With the help of Walker, Eastman then borrowed the ideas of Leon Warnerke, a Russian immigrant to England, who had already designed a camera with a roll holder that used a continuous roll of collodion tissue, the substance that had been used to capture images in wet plates. The roll holder contained two rollers on which the sensitive tissue was wound. The holders had a red glass opening that permitted the photographer to observe the numbers on the back of the sensitive tissue. The film consisted of glazed paper with alternate layers of collodion and India rubber and then the photosensitive emulsion. After exposure the emulsion was stripped from the paper and attached permanently to glass plates. In the 1870s Warnerke had covered the stripping film with very insensitive dry collodion emulsions. Although in the early 1880s he sought to employ dry gelatin emulsion, he encountered difficulty in drying this tissue while the gelatin was attached to it and in modifying the measuring and marking mechanisms in the roll holder to compensate for the greater sensitivity of the gelatin emulsions.

The principle behind Warnerke's roll film system was truly a great advance for the existing dry plate technology. Although the system received attention in the British photographic journals during the decade 1875 to 1885, it never made a commercial success (Jenkins, 1975). The system was criticized on five counts: the stripping film itself was very expensive to manufacture; the rollers were fixed permanently which necessitated the awkward task of putting the film on and off the rollers in the camera the indexing required a small glass window which allowed some light to enter; the tension in the film had to be maintained which became a problem when weather varied.; and finally, the actual products were unreliable because of the handicraft method of building them. Eastman designed new machinery to mass-produce these cameras to accurate specifications, thus improving the reliability, finishing and quality of the cameras.

Eastman's stated mission at the time wasto engage in the manufacture of Gelatin Plates [dry plates] on a large scale and through innovations in the manufacturing process, take the prices down to a level where miscellaneous competition would be driven out. However, as Jenkins emphasizes, Eastman found that all his calculations and strategies were not fully successful, and his plate-coating machinery patents did not provide adequate protection against potential competitors (Jenkins, 1975). Taking advantage of the protection that patents offered, Eastman soon extended his traditional patenting strategy to both product and process. By 1884, new machinery had been developed and patented for the production of roll holders, film and cameras, as were the designs for all these products. In the spring of 1885, the Company marketed the roll holders, which received accolades from a number of American and British photographic journals.

Issues

Roll-film technology's introduction to the institutional context discussed above, prompted several issues. The first and foremost issue was whether it was needed at all

While it was widely conceded that the idea behind roll film was quite innovative, great skepticism existed regarding its potential in the market. The quality of images was poor and the loading and unloading of film complicated. While the camera did offer more mobility, this feature could not compensate for other drawbacks.

The Need for Roll-Film Cameras

As recently as the 1880s, the great majority of Americans had for the most part "never entertained the thought of taking a photograph, let alone pursuing the complicated operations of developing and printing that were required following exposure" (Jenkins, 1975: 112). What would happen if the average person could take a picture without all those complicated operations? No one knew. In fact, this question did not even occur to anyone. Tedlow (1997) likens the mind shift that popular photography entailed to Copernicus' proclamation that the earth moved. Copernicus's critics, Tedlow (1997) argues, were not either just wrong or quite wrong. Part of what they meant by "earth" was fixed position. Their earth, at least, could not be moved. Correspondingly, Copernicus' innovation was not simply to move the earth. Rather, it was a whole new way of regarding the problems of physics and astronomy, one that changed the meaning of both "earth" and "motion." (Tedlow, 1997: 149-50). Similarly, prior to the 1880s, part of what people meant by the word photography was an elaborate chemistry set and all those "complicated operations." What would photography be if you could have the picture without the expertise? Eastman himself well understood that no one "needed" a camera or a picture in the sense that people need food, clothing, and shelter. The thought that several million potential customers for some new type of camera existed out there never entered his mind, or at least was not reported to have.

At this juncture, the introduction of roll-film cameras, which did not meet the expectations associated with photography as well as the dry-plate cameras did not seem too remarkable to most firms in the field. In fact, until Eastman, because of mounting pressure to stay competitive in the mature industry, no one had seriously considered producing Warnerke-like designs on a mass scale. Dry plate cameras had been institutionalized in every sense. That is, it was established for a 'fact' that the only challenges before organizations were size reduction, simplification and efficient/

competitive manufacturing of current designs. That there could be a mass market for these convoluted apparatus was widely realized, but no other design was considered a better alternative than the dry plate cameras presently in use, when it came to serving market 'needs.' That they had to carry glass plates along was not considered a problem by the existing market of professionals and serious amateurs and the rest of the population did not seem too worried about the fact that they could not take pictures themselves.

Indeed, such was the disdain towards this innovation that the other formidable players including Anthony did not even bother with this new contraption, not because they were unaware of it but because of their deeply entrenched positions and massive investments in the design, manufacturing, distribution and marketing of existing technology, and belief that such equipment could not be competitively manufactured, sold and used[17]. It was widely believed that it was not even needed! Indeed, for seven years after the introduction of roll-film cameras, E. & H. T. Anthony & Company persevered in its outright rejection of the roll film system and the continued promotion of traditional plate cameras. The other big player, Scovill Manufacturing Company was a little more accommodating. It reacted to the roll-film technology as a niche business. Thus, while they responded favorably when the roll holders were first introduced, promoting them, equipping their cameras for them, and obtaining a license to produce them for their own cameras, they stopped when the Kodak camera's inroads into their own camera business became quite manifest.

Eastman, however, as mentioned before, relied upon Anthony for the distribution and marketing of its dry plates and did not share the high regard for image 'quality' with his competitors. His profits were also being squeezed in the dry plate business, and thus he decided to diversify his product line by developing and patenting this new kind of roll-film camera. The new camera, if successful, would allow photographers to roam around and take pictures without having to carry glass plates with them. They would, however, have to transfer their images to glass plates upon returning to their studios. From thereon in, the whole process was no different that what was being practiced.

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[17] Several people by the time had developed such roll-holder cameras including a farmer from Wisconsin, David Houston (Jenkins, 1975).

Quality and Complexity

As discussed above, in an era dominated by painting as the primary technique for graphic representation, accurate representation of subjects was considered the distinguishing feature of photography. The ability of cameras to capture detail, while considered inartistic, was highly valued. ‘Quality,’ naturally, was a product of several things, including the professional photographers’ knowledge of chemicals and developing procedures, the quality of film, the workings of a camera and the development technique. In order to produce images of high quality, Eastman had to ensure that this chain of activities and artifacts was tightly linked and ready to deliver. However, several obstacles stood in the way of quality. First and foremost, photographers had to learn a completely new technique, loading and unloading film into a complex mechanical contraption. Then there was the transfer of images from the stripping film to plates, another complex and delicate process. There was of course, no incentive for them to invest time and energy into learning this technique.

Secondly, the production of film was at an experimental stage. Kodak was entering completely uncharted territory with the mass production of film, and consequently experiencing major difficulties. While the mechanism was operative in a rough sense, it was difficult to manufacture reliable film for the system. Also, film blistering was a recurring problem. In order to supply a film for the roll holders, a paper strip was coated with regular dry plate emulsion. This negative paper film was not nearly as satisfactory as a transparent film because the printing had to be done through the grain of the paper, giving the prints a washed-out, faded, or even grainy appearance. Paper was treated with light oils before printing helped increase the transparency but the paper film was never popular. The introduction of stripping film, or American Film, was delayed until late 1885. The photographer's operation with the stripping film was so complicated and delicate -- development, soaking, separation, squeegeeing, and varnishing -- that even during 1886 American Film was not promoted. Furthermore, its production required three times as long as that of negative paper. The Company policy was to persuade photographers to purchase the roll holder and acquaint themselves with its operation using negative paper and then hope to introduce them to American Film later, when they already knew how to use the roll holder. By 1886, Kodak was marketing a transparent film for roll cameras, a significant improvement over the previous films. Still, Eastman found it difficult to penetrate the market. *By late 1887, the Company had openly admitted the failure of the roll-film system to replace the glass plate.*

The current market unanimously considered the roll-film system an interesting idea but in practice vastly inferior to the dry plate designs available then. Eastman had now considerable investments in a design that had essentially failed. He had a plant set up to produce films which were sold under the name American Film, roll holders, and cameras. He also managed a service line that was essentially a byproduct of the film system[18]. While the film system was not truly successful, this service line did prove to be a prosperous line of business.

TECHNOLOGY, ISSUES AND KODAK'S STRATEGIES: THE EMERGENCE OF A NEW DESIGN

In 1887, having admitted the failure of roll-film technology, Eastman Kodak had several options before it. It could go back to dry plate manufacturing in which it still had a sizeable presence, it could further invest in roll-film in the hope of increasing its quality and reliability, or it could focus on a different market. While Eastman finally chose the third option, it is not entirely clear if this was the intended or simply the emergent strategy (Mintzberg and McHugh, 1985). Indeed, Eastman tried several new materials for film and the emulsion and different designs for the camera which resulted in only incremental advances in quality. Moreover, discouraged by the failure of the negative paper and stripping films to gain popularity, Kodak decided, in 1886, to include a plate holder in the new camera. This indicates that Kodak was not dreaming of a mass market, but trying to tailor its design for the existing one.

[18] The development of coating machines for the film stimulated the introduction of machine-made continuous-roll presensitized paper. Eastman's Permanent Bromide became a major sales item as the Company developed American markets and utilized its new London branch to promote introduction of the new paper in Europe. Furthermore, the production of this paper, especially in the bromide developing-out printing paper, stimulated the opening in the early spring of 1886 of a printing and enlarging service.

There were several influences on the course that Eastman ultimately adopted. There was, for instance, Eastman's considerable investment into research, development and manufacturing of roll-films, his increasing realization that his technology could find greater legitimacy among non-photographers, and a myriad of institutional changes that were coming about. In this section, I describe, how given these influences, Eastman's technology transformed in response to issues of quality, convenience, complexity and 'need' in order to catapult it to unprecedented, and unimagined success.

Exploring a New Field

While Eastman's roll-film camera was unable to garner sufficient legitimacy in the existing market, it was becoming increasingly apparent to him that another segment of the market was more willing to bestow much needed legitimacy on his design -- the people who until now only consumed photographs in their social capacity. Whereas the structure in the existing institutional field was difficult to change, these people provided a field that the roll-film technology could structure. The inhabitants of this (potential) field were not very worried about the quality of photographs it seemed. Increasingly, the major players in the photographic field were beginning to target this new set of consumers, albeit with their existing technology. This group was experiencing rising incomes, travelling more and enjoying more leisure. In other words, a new cultural space was being created into which the practice of photography could be inserted. Eastman himself was a member of this consituency: the non-professional.

It appeared that the sources of legitimacy in the emerging mass market for photography were different. Until now the majority of Americans had only been consumers of photographs, not producers. And in that capacity, they valued photographs (taken almost always by professionals) of exceptional quality. However, when it came to taking photos themselves they had much lower standards. It appeared that the *mass market associated high quality with professional training, not with the apparatus.*[19]

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[19]In my interaction with lay people, I have observed that even today, most people think film development and printing, which has in fact the largest source of variation in quality, is standard across all photofinishers and thus attribute bad quality to their own incompetence or to their cameras.

The period from 1890 to 1910 represents a crucial juncture in the photographic history. During this time, the fortunes of the roll-film camera and Eastman were reversed. Figure 4.1 depicts Kodak's increasing market share of the industry while 4.2 proves that this dominance was not attained through its traditional dry plate business, which was actually on the decline. A design that had all but failed, was not only revived but became *the* way photographs were taken for the next 100 years. As discussed above, manufacturers had been attempting to make photography an activity for the masses, and Eastman had been peddling the roll-film design for a few years without any luck. What, then, were the changes in the environment and in Kodak's strategy that brought about this significant change? In this section, I describe how the roll-film technology was re-positioned in an environment that had been changing for some time. It was not, it appears, the technology, which changed or that people suddenly 'needed' cameras. Rather, it was Eastman's structuring of a new market and creation of a new field which linked photography with new emerging institutions and inserted it into everyday lives a strategy other players were unable or unwilling to adopt[20].

Figure 4.1 & 4.2 About Here

Most of the developments in the roll-film camera took place between 1880 and 1920, a time characterized by the optimism of a new century and the de-moralization of a World War. During this period, there was a shift in Americans' personal and collective notions of temporal and spatial experience, as well as personal and collective claims to social and physical mobility [21]. This was an important period of transformation for the organizational environment characterized by expanding markets and falling prices and culminating in the merger movement whose attendant internal and external changes have been termed the "Corporate Revolution" (Jenkins, 1975; Chandler, 1959). A number of

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[20] Up until 1900, camera manufacturers had been inviting people to adopt photography, without changing the institutional context in which people made sense of photography. They created smaller cameras to cater to changing lifestyles, but were not able to see beyond the institutionalized understanding of photography as a way of capturing images accurately. They were willing to reposition photography only as much as their existing technology in which they had major commitments allowed.

[21] Stephen Kern (1983) and Peter Gay (1984) among several others, have stressed the critical importance of WWI in the American 'bourgeois experience.'

forces converged during the period preceding the Corporate Revolution that enabled entrepreneurs to engage in novel strategies for dealing with this rapidly changing technological and business environment. The railway network had basically reached its geographical limits by 1880; a growing national and urban market reflected new tastes and improved incomes; and high tariffs and the traditional ocean barrier protected the domestic market (Chandler, 1959). At the same time, improved production technology promoted economies of scale, which resulted in falling prices and increasing competitive pressure among manufacturers. A mass consumption culture was gradually forming and national markets developing. In several arenas, including art and music, mass production technology brought about a democratization much resented by the elite. In photography, similar currents were underway, with Kodak managing these to its advantage.

Roll-film technology made the most sense in a context where picture-taking was a popular, social and ubiquitous activity, rather than a specialized one carried out at only selected occasions by professionals. At the time Kodak introduced its technology, the context was more of the latter type than the former. Kodak mediated in the several tensions present in the environment, including the one among professionals, amateurs and the masses, and the changing role of women in the family and outside, embedding the roll-film camera permanently in the new networks and institutionalized understandings of roles and relationships. In the following paragraphs, I discuss how Eastman intervened in ongoing social dynamics in the society in an attempt to define photography so that its roll-film technology became the obvious choice (Table 4.1 summarizes the following discussion and lists Kodak's attempts to redefine photography and how they were supported by actions in the social and technological realms).

Photography's Journey from Professional to Amateur Activity

As discussed earlier, photography until the 1880s was largely a professional activity. 'Professional' meant that it required specialized knowledge, and much initiation on the part of anyone desirous of practicing. These 'professionals' followed prescribed rules, technical standards and the unwritten code for photographers (such as valuing precision over aesthetics. Above all, this selected group guarded its boundaries rather jealously and had little concern for whether or not the 'masses' would like to become photographers. The majority of photographic manufacturers shared this code.

Professionalism epitomized the organizational logic of industrial capitalism that worked to control labor through the institution of work standards, the white-collar "corollary" to standardized parts and Taylorized assembly line work (Zimmerman, 1995). The professional -- drilled, disciplined, methodical, dependable, and knowledgeable -- embodied capitalist production methods. Amateurism emerged between 1880 and 1920 as the cultural inversion to the development of economic professionalism. With labor increasingly rationalized and craft-persons and inventors subsumed into corporate organizations, professionalism reproduced highly trained individuals as efficiently as mass production standardized interchangeable machine gun parts. In contrast, amateurism was not perceived as being standardized or interchangeable, yet it was clearly identified with upper and middle-class leisure. As Zimmerman notes, amateurism postured as the aesthetic antidote to the total stagnation of the professional (Zimmerman, 1995).

Amateurs were normally people who took photographs as a hobby, rather than for a living. Amateur photography symbolized adventure, technical skill, modernity and a developed artistic sensibility. Amateurism, however, also inherited the status-related cultural baggage attached with painting. Indeed, photography had been framed as an off-shoot of the deeply entrenched institution of 'art' since the time when it was confined to serious amateurs. Photographs were judged on the same attributes as paintings were, although it was at most considered a "middle-brow" type of artistic endeavor (Bourdieu, 1996). A 1896 review of amateur photography in the American leisure magazine, *Cosmopolitan*, for instance, encouraged amateur photographers to study great art work, claiming its visual organization would train the amateur to see the world "artistically" that is, according to the principles of dominant, museum-preserved traditions in art. Some well-to-do amateur photographers even studied with painters to hone this traditional painterly sensibility (Johnson, 1999).

At the same time, amateur photography carried the connoted adventure and travel, thus representing a status symbol. It was one thing to own a hand camera which were becoming more systematically more affordable, but it was certainly another to be able to show that one had traveled abroad in possession of one. . Vacations were no longer only pursuits of pleasure, but their significance increased manifold because they could now be recorded and displayed as a symbol of the vacationer's experience, leisure afforded by increased wealth and worldly knowledge.

Kodak's efforts to equalize and engineer the acceptance of image-making as a desirable leisure activity for the many were all part of a process of making common the pursuit and practice of image-making, and defining social uses of photography. The Company's own publication for amateurs, *Kodakery*, introduced in 1903, supplemented the Company's continued efforts to carve out an amateur public of photography consumers, and to carve them out specifically as Eastman Kodak customers. *Kodakery* adhered to Kodak's other organs of distribution and promotion like road shows which had already begun to nourish image-making as a popular pursuit, and to showcase photography's infinite uses.

These strategies, while eventually enormously successful, were not a product only of Eastman's vision or foresight but a reflection of strengthening trends in the environment. It could be argued that Eastman was the principal agent of change simply because he was less immersed in the professional photography culture than his main competitors, who were all professionals themselves. The trends were an economically strengthening bourgeoisie, which displayed an increasing tendency to quickly adopt photography as a pastime and thus associate themselves with the culturally and technologically more sophisticated upper classes. This was a tendency that Eastman encouraged whole-heartedly, belonging to this class himself (Johnson, 1998). He advertised in a repertoire of journals catering specifically to amateur pursuits which had just appeared on the scene: The *Photo-American*, *Paines Photographic*, *Camera* and *Darkroom*. His own journal, *Kodakery*, in addition to Sears Roebuck's *Better Photos*, directed the audience's attention to family-oriented production and consumption and sought to fill their leisure with photography-related activities.

Photography: An Activity for the Masses?

Kodak's camera, the No. 1 Kodak, proved to be the main vehicle on which amateur photography thrived. Its $25.00 retail price, while out of reach for most, was well within reach of amateurs. These amateurs valued Kodak's compactness and portability, which enabled them to take it along on trips. At the same time, however, they valued quality, which signaled technological sophistication. Thus, Kodak's move to compromise its already poor quality in favor of cheaper cameras was a bold one. While the Brownie, introduced in 1900 and available for $1.00, took poor quality photographs, did not force users to develop their own photographs, and appealed to the masses. In a radical departure from the norms, Kodak separated photography from photo development, thus diffusing the issue of complexity. By taking care of developing itself, and transforming the complex camera into a box where one just had to 'push a button,' Kodak redefined the camera and with it, photography. Eastman Kodak's promotion of simple cameras reshaped the scientific discourses of 'truth' and 'material evidence' as novelties for sale and for pleasure. The box Brownie – the camera for a buck – was the prototypical novelty, and quite different from the professional No.1 Kodak camera. For leisure, hand cameras cast a far-reaching net over a wide world of potential lay-photographers. The depth and breadth of this 'casting' suggested a belief in both the democratization of image-making practices, as well as the idea that image-making was a democratizing and democratic practice.

Naturally, this move did not fail to elicit a sharp reaction from amateurs and professionals. This 'democratization' of photography threatened to change the connotation of an activity that they held dear. To professionals and serious amateurs, photography was losing its stature as an 'art' and a serious pursuit. Eastman cast a completely different light on this technology by advertising in 'non-photographic' magazines such as the *Ladies Home Journal*, *Harper's Bazaar, Harper's Weekly*, *Scribners*, *Century, Harpers*, *Popular Science*, *Outing*, *Scientific American*, *Frank Leslie*, *Puck*, *Judge*, and *Life*. The Company's first national advertising campaign showed Kodak cameras in use "for every possible purpose." In a letter to one of his graphic designers, Eastman, overseer of Kodak's advertising affairs, ordered a series of pen sketches depicting individuals and families out and about with 'Kodaks' in a variety of activities which included sports travel, family leisure, parties, and so on. Mobility, activity, and family accessibility were significant denominators for Eastman's campaign, as were women.

Similarly, in 1905 Eastman Kodak took to the road putting the practice of photography on exhibition all over the US. Shows included lectures and demonstrations, lantern slides, pictures, and even motion pictures to fill gaps between photographic demonstrations as "fillers and entertainers," (Eastman Kodak Company Trade Circular, 1912: 2). The aim, much to the resentment of serious amateurs and 'artistic' photographers, was to make roll-film cameras part of everyday life. A distinction was soon drawn between 'photographers' and 'button-pushers.' Those who snubbed the popular appeal of the hand camera and roll film process did so on the basis of the way in which it debased claims to the purity of the photographic arts. The derogatory remarks lodged against those who pushed and participated in the hand camera 'craze' were fueled by an apprehension toward the new social phenomeon of 'button pressing' and its aesthetic implications. It must be noted, however, that such criticism, seeking to marginalize the new practice of image-making and its legions of followers was normally found in very specific and specialized photographic and photographic club journals.

One example of such resentment was embodied by Adelaide Skeel, who edited a regular column in the highly popular photography journal, *The Photo-American*, called "Our Women Friends." Skeel attempted to bring women into the practice of image-making by establishing a forum for dialogue. "Our Women Friends" debuted in 1891 and was directed at female consumers of photographic equipment and producers of photographic images who sought and shared image-making advice. The correspondence featured in her column factored into a sophisticated and technical discourse, which evidently dominated the voice of "Our Women Friends." Ostensibly, the letters selected by *The Photo-American* for publication under this column all came from women, even though in reality most of those who wrote to Skeel were men. The following excerpt from a letter written to "Our Women Friends" exemplifies her attitude towards button pressers:

> Dear Women friends, I am so glad you are all coming together to help us make something more than a tiddledy-winks pastime out of photography. I do despise "button-pressers" in anything, and that is because I have been to Vassar. (quoted in Johnson, 1999).

Such "high-brow" sentiments were also voiced by several eminent photographers opposed to the unbridled popularization of the activity. Alfred Steiglitz was perhaps the most well-known of opponents to popular photography as it had been redefined by GE write out GE (Johnson, 1999). Steiglitz, himself an accomplished and pioneering photographer, considered image-making a "dignified" art and skillful practice, and feared that the practice could only be debased by the new photographic technologies that removed social barriers to photography by accommodating "anyone" who wanted to make images.

However, Kodak pushed ahead with its democratization program for photography. It sought to make image-making a common and bourgeois pastime in addition to a common denominator in the provision of evidence of "good" living, just when the potential for achieving "good" living trickled beyond a conspicuously "leisure class." The Brownie was promoted heavily. Its popularity, simplicity, and low cost prompted many merchants to add Kodak cameras as a sideline. Indeed, the brownie was designed with the idea of mass production in mind since its cardboard body and highly simplified mechanisms could be efficiently and cost-effectively reproduced. To promote it, Kodak pilfered the product's name and caricatures for its package design from contemporary and well-known, children's book author Palmer Cox's popular storybook characters, "The Brownies." (Johnson, 1999:129). Eastman explicitly appropriated the iconography from one popular cultural artifact to champion the popularization of another: "Plant the Brownie acorn and the Kodak oak will grow". In other words, start them young and germinate many lifetime customers.

The Brownie, not surprisingly, was promoted in youth oriented publications such as the *Youth's Companion*, and women's and family-oriented ones like the *Women's Home Companion* and *Ladies' Home Journal*. It was not exclusively imagined to be the purview of youth even though this is where the Company's attentions were dominantly focused. I distinguish this simple box camera as representing the diversification of amateur "publics" along the lines of generation and gender. On the eve of its market introduction, Kodak wrote the following note to dealers:

> "Although of simple construction, this is a good, honest little camera that will delight the heart of any boy or girl and will, we have no doubt, make thousands of customers for instruments which have greater capabilities." (quote from *Kodak Trade Circular*, 1900, cited in Johnson, 1999).

The Brownie, then, was expected to fit into both a technological lineage in the family by upgrading to or being situated alongside more complex technologies, and a generational lineage where Brownies were the starter apparatuses for boys and girls.

Photography: An Activity for Women?

Kodak democratized photography not only across classes, but also across genders, inviting young women to adopt it, ultimately making the taking, collecting and displaying of family pictures a part of their responsibility in their role as housewives. Since leisure was initially restricted to the upper class and photography was considered a suitable activity to fill leisure, it was no surprise then that wealthy women first took up photography. Of course, they too were subject to social norms. Photographing one's family, friends and home, and unobtrusive social escapades were all considered legitimate, even desirable, for well-to-do ladies. As long as image-making was practiced in familiar social contexts and, even better, for domestic and family purposes, the controversial aspects of women's appropriation of photographic apparatuses were sidelined/marginalized. There was, however, dissension among the ranks as to whether or not it was, in fact, ladylike to "Kodak" under any circumstances. To the other extreme, there was also dissension as to whether or not women's uses of photographic apparatuses would overtake the practice of family rearing.

Soon after the introduction of the No.1 Kodak, Eastman wrote to a designer:, "we want a drawing of the figure of a lady stylishly and suitably dressed with a Kodak case slung over her shoulder and a Kodak in her hand in position to make an exposure" (p.117). In 1889, the first advertisements appeared featuring a "Kodak Girl," a smiling, young and fashionable woman aiming her Kodak. The Kodak Girl symbolized the modern, adventurous, independent female and was soon to become the Company's central image. Featured first on posters and then on six-foot cardboard cutouts, the Kodak Girl models also made live appearances at stores. The Kodak Girl soon became the feminized icon memorialized in Eastman Kodak advertising copy from the 1890s until the 1960s. She was not only a suggested camera operator, but was also one to be photographed. A certain amount of social skepticism, however, intervened in the cultivation of photography as a popular leisure pursuit. These "machines" and the kind of invasive social circulation their appropriation suggested were not considered particularly "ladylike" and conjured notions of "a modern girl" with which existing social mores were unfamiliar. This unfamiliarity was short-lived, however. With its rapid succession of increasingly simplified camera models throughout the 1890s and culminating in the Box Brownie in 1900, Kodak intervened in the moral divide between women and cameras. His product advertising strengthened the connection between women, cameras and family until, by the turn of the century, it was hardly a moral issue. In fact, it had become a moral imperative to record family "history," and to seek out pleasure in images, their production and consumption as an inclusive family activity.

Before the hand camera craze made image-making more accessible and more popular, women had to find and form their own networks for the exchange of photographic knowledge. Such networks were most commonly found in popular magazines, and in popular photographic literature. Although the number of people who used cameras had increased after 1888, women's access to knowledge networks and established photography clubs were limited except in terms of the outlets provided by popular magazines. However, after the Brownie had put image making within reach of the masses, attitudes toward women and image-making "machines" cooled. Popular literature, however, still directed camera consumption and image production toward women only within very particular social roles and social institutions: brides, mothers, wives. "Modern women" was a term used at the end of the 19th century and well into the 20th to signify young women who separated themselves from conventional gender roles. "Modern women" actively engaged in the practice of photography from the early years of its popularity.

While Kodak's poster girl stood in opposition (literally as a cover model, standing with a Kodak) to the prevailing gender ideology, it would be a mistake to read Kodak's peddling of the "Kodak Girl" and Vanity cameras as a feminist act. Indeed Kodak designed 'Petite' cameras and an art deco line of Vanity Cameras purely for profit. They came color-coordinated in a variety of shades for "modern girls" and were not necessarily intended for being with the family, but perhaps for circulating in work and social worlds as the built-in compact for lipstick might suggest.

Photography: A 'Family' Activity?

Since families provided the enclave where women could legitimately practice photography, they were the ones to carry the camera into family life. Eastman recognized this social dynamic and built upon the emphasis on women as 'efficient' housewife and encouraged women to create family histories through photographs. The first series of sketches commissioned by Eastman for publicity purposes depicted "families" and alluded to the celebration of children, in particular middle and upper-class children and families. The initial wave of commentary and promotion that sustained the No.1 Kodak and Box Brownie immediately pervaded U.S. households. The *Kodakery* journal directed attention to family-oriented production and consumption which encouraged the recording of 'family moments', later to be known as 'Kodak moments'. When it came to the family, cameras were considered less an artistic apparatus, instead they were equated more with the photo-realist documentation of personal and family life. This is not to say that representational and aesthetic practices beyond the family were severed from ideas regarding personal appropriation. Rather, it is to suggest that when it came to the promotion of Kodak's low-end apparatuses, such as the Box Brownie, the matters of memory, history, and their relationships to family took precedence.

Instead of framed positives, which were always professionally developed from dry plates before the roll-film camera, Kodak also encouraged the preservation of images in photo albums, which would serve as an archive of family lineage and contain all the beautiful memories in the family's history. Publications like *Kodakery*, and Sears Roebuck's *Better Photos*, diligently promoted the production of photo albums and photo calendars, with an emphasis on the former. The idea was that action picture books, albums, and picture diaries could and should be shared with friends and relatives to repeatedly share experiences and to solidify family history. Impromptu home pictures of the children would yield variety in such chronicles. Variety and diversity were virtues all album keepers would strive for.

By making picture-taking at every family occasion an imperative, Kodak revamped image-making, originally an individualized practice, by turning it into a social one. The Kodak's advertisements always depicted groups of people , together and using cameras, usually families. When it did depict "individuals" like the Kodak Girl, it catered not to sequestered, individualized and even alienated notions of production but to socially integrated ones that located shutterbugs? in the world of new leisure fancies, travel and family. Advertisements and production literature consolidated the familial and bourgeois prominence of image-making, especially with respect to babies and children. In the figure of the child, as both photographic subject and camera operator, lay the dual promise of the future as well as the present-oriented privilege of personalizing perceptions of history in photographic images. These personalized perceptions would always be rooted in social production and consumption.

> For Kodak, family appropriation by far outweighed attention to individual and specialized notions of photographic consumption, although the Company was careful not to alienate specialization either. Its strategy to augment the mass-popularization of image-making as a conduit to familial aggrandizement is revealing in that it draws attention to an entrepreneurial and industrial zeitgeist for defining "family" as a viable component in the consumption of amusements, goods and services. It, along with other entrepreneurs and businesses such as the department stores, demonstrated foresight in its recognition of a rapidly growing bourgeois "class" with the potential to dispense with their disposable incomes. George Eastman was one of them, and as Johnson has argued, who better to capitalize on the distribution of new wealth than someone who shared an affinity for it? (Johnson, 1999).

By 1920, photography was associated with completely new normative and cognitive institutions. It was no longer a technologically daunting 'alchemy-like' process in which a few brave souls engaged. Instead it was fast becoming a popular pastime, defining weddings, birthdays, picnics and a host of other occasions. Vacations were no longer complete without a camera with which one could re-enact one's adventures for the audience back home. Albums, which chronicled the history of each family were now firmly established as a new institution. To the great disappointment of the pioneers of photography -the professionals and serious amateurs who had been socialized in the culture of dry-plate photography-, the new cameras did not offer a quality comparable with dry-plates. As long as people were recognizable, a photograph was deemed satisfactory, it seemed.

Photography and WW I

While Eastman Kodak displayed an impressive familiarity with the changing social dynamics in its environment, it was quick to exploit other more transient opportunities of entrenching its technology in the hearts and minds of the masses. For instance, its exploitation of the First World War was remarkable in its contribution to the institutionalization of the roll-film camera as an essential family possession. Kodak's publicity focused on the event of soldiers leaving home, and the unreliability of memory in terms of remembering what loved ones looked like. The War was an event, and while a serious one, the documentation of soldiers off to battle was a logical substitute for civilians on vacation and/or play. Once again the versatility of the hand camera could be adapted to the social and emotional needs of the people who used them. Indeed, the first pen sketches for the No.1 Kodak's 1888 promotional campaign illustrate this, as do the much later departures and arrivals of soldiers off to two World Wars. It might have been a family tradition to celebrate certain events and rituals in specific ways, but having a camera along to document events became its own tradition in the domestication of image-making practices. The Company's Autographic camera and Autographic film, short-lived experiments in image-making introduced in 1914, were strongly linked to the establishment of dates, times, and places. With the Autographic camera and film, notes could be written directly on the film at the time an exposure was made. The Autographic and other cameras bridged the divide between home and barracks, and home and battlefield.

Technological Transformations: Formation of a Network

Through its pioneering campaign, which sought to embed photography in everyday life, Kodak changed the focus of debate with respect to several issues identified. Indeed, what photography meant or stood for had dramatically changed. Within it was embodied several new connotations about users that older technologies could not meet. Cameras were now an everyday device that could and should be used both within and outside the home, by men *or* women, and which was and should be an essential companion on vacations, or any social occasion, adding 'fun' to the event and preserving memories. Similarly, issues of quality, complexity, portability etc. were completely re-framed. Quality was superseded by accessibility, complexity eliminated by subsuming the development task within the organization and portability taken to new levels with daylight loading film. Table 4.1 summarizes how Kodak opened the roll-film system to incorporate and settle issues.

It must, however, be noted that Kodak's initial roll-film models neither embodied this meaning, nor were they capable of meeting the requirements, which went with such claims. For instance, the earlier technology was complex, expensive, produced poor quality images and required darkrooms to load and unload film. As Kodak positioned photography as an activity for the masses, some of these issues were re-framed. While professionals had derided the cameras for their poor quality pictures, the masses seemed comfortable with pictures as long as the subjects were recognizable. Moreover, the threshold for complexity was much lower here. Finally, wide availability of service and development services was a prerequisite for this technology to be successful in the mass market. Unless Kodak built a network of agents who were committed to the design, Kodak could not hope to deliver on the claims of simplicity, availability and technical superiority it had made to the users. In short, it needed to enroll the support of several agents who could provide chemicals, various specialized parts, manufacture cameras and sell and develop film.

Enrolment, however, was not a simple task especially when the 'superiority' of the roll-film system had not yet been established. Indeed, most firms, including the largest, E. & H. T. Anthony & Company outright rejected the roll-film system and the continued promotion of traditional plate cameras. Scovill Manufacturing Company, another large player responded favorably when the roll holders were first introduced, promoting them, equipping their cameras for them, and obtaining a license to produce them for their own cameras. They likewise responded favorably to the Kodak camera but only until its inroads into their own camera business became quite manifest, at which time they ceased promoting this technology.

Naturally, the strategy of enrolling stakeholders in the new photographic system had to contend with the issue of control. While Kodak wanted stakeholders to adopt the roll-film system, it wanted to retain control too. It relied on patents and aggressive, often anti-competitive acquisitions in order to achieve this objective. While Kodak's attempts at making photography a 'mass' activity was proving to be successful, several smaller companies were beginning to enter the fray, bringing with them various versions of the roll-film camera. In order to eliminate all competition to its design, Kodak began to acquire all patents that posed, in one form or another, a threat to the protected position of the Company's roll film system. And in the process of acquiring these patents the Company also acquired several small firms that owned or controlled them. The motives behind these acquisitions were complex. First, the acquisition of patents would strengthen and temporarily extend the patent barrier around the system. Also, litigation could be avoided through purchase of patents and companies. Infringement suits, either by a patent holder against Kodak or by Kodak against an infringer of its patents, were expensive. Furthermore, the charges and countercharges of competing companies in the marketplace regarding contested patents could hurt the public reception of the new roll film system of photography.

It is interesting to note that during the next decade, the 1890s, fewer of the major technological innovations came from the Eastman Company and more came from the new and struggling firms that were seeking access to Eastman's markets. Those innovations that provided modifications of the roll film system played a significant role in the technical character and popular success of the roll film system of photography. However, the sources of these innovations, generally smaller start-up companies, were purchased outright by Kodak.

Corporate takeovers, patent acquisitions, and patent retirements were methods that Kodak used to insulate its processes, and most importantly film processes, from direct competition. For instance, Boston Camera Manufacturing was purchased because of the combination of patents it owned that allowed it to effectively circumvent the Eastman roll film system. Since the Turner daylight-loading cartridge patent had just been issued and, therefore, still had nearly the full seventeen years to run, Eastman perceived that acquisition of that patent could prove highly significant in the continued long term control of the roll film system. While Kodak did acquire ownership of the Turner daylight-loading cartridge patent, it did not obtain control of the Houston patents on the front-roll system of roll film cameras. The desire to acquire these important patents led to the acquisition of the American Camera manufacturing Company in 1898. The following year, Kodak acquired Blair Camera Company for its patents. This was in addition to the purchase of patents such as that of Bostwick and Harrison from several companies that could threaten the design, production or service of roll-film cameras in any way.

It must be noted that Kodak was not solely interested in buying patents on film. It bought patents on camera design, production machinery, emulsion, film material, roll-holders, photofinishing techniques and so on, culminating in their control over a complete 'system' of photography. This control was carefully maintained mostly through acquisitions and even strong-arm tactics. For instance, Kodak supplied roll holders to Blair Camera Company which sold them to Boston Camera Company which took them to the market. Since Kodak had difficulty meeting the demand for film, Eastman carefully restricted the flow of roll holders to the market in order to avoid customer dissatisfaction with the inadequate supply of film. Blair failed to understand this and began to lay plans for production of both roll holders and roll film. When Eastman heard rumors of Blair's plans, he discontinued shipping roll holders to Blair in October 1890.

As part of the 'system' creation strategy, Kodak added an entire network of film sellers and developers to its network. At first the photographic supply houses were the only establishments for the distribution of the popular Kodak camera and the roll film, but this old network proved to have too few retail outlets to meet the needs of the new market. During the 1890s the sales department at Kodak broadened its network to include thousands of drug, jewelry, optical, department, and hardware stores, which carried Kodak cameras for amateurs as a sideline. Two major stimuli to the development of a nonprofessional network were the introduction in the mid-1890s of the daylight loading cartridge, which freed the user or dealer from the delicate operation of removing the film from the camera in a dark room, and the introduction in 1900 of the popular Brownie camera. The popularity, simplicity, and low cost of the Brownie prompted many merchants to add Kodak cameras as a sideline.

The progressive lowering of Kodak's costs, achieved through economies of scale popularized the cameras further among the amateur market. At the same time, the design continued to be simplified. Indeed, the Brownie's ease, simplicity, and affordability said something about technological innovation and the new industrial techniques for mass-production, and even more about a newly-defined and socially-categorized "mass" of image and camera enthusiasts who had emerged over the previous 12 years. It was the technological realization of a process with which Eastman Kodak had set out to re-invent photography as a mass-popularized leisure pursuit. The shape and size of photographic hardware were simplified as was the design and processing of software, for example film instead of plates. It was thus easy to manufacture for those who were interested in licensing the system.

Similarly, by re-arranging the consumption chain from one where individuals had to develop their pictures themselves, to one where Kodak did all the developing Kodak took photography into the realm of the layperson. The Kodak No. 1, for instance, came loaded with a 100 exposure roll, sold for $25.00 and was so simple that the novice photographer had only to turn the key, pull the cord, and press the button. After the film had been exposed, the entire camera was returned to the Eastman factory where the exposed film was unloaded, developed and printed. The developed film, print, and the reloaded camera were returned to the novice photographer. This process was made simpler with the introduction of the first daylight-loading film in 1891. This meant that photographers no longer needed to be in a dark room to reload their cameras. Following thatthe Pocket Kodak camera was introduced in 1895 and five years later, the first of the famous Brownie cameras was introduced. In 1902, the Kodak developing machine simplified the processing of roll film and made it possible to develop film without a darkroom.

Through all this, Kodak's central strategy remained the retention of control over the technology, or better yet, the practice of photography. It continued with its dubious tactics. For example, one of the problems that Kodak faced in the middle and late 1890s was that many of the dealers that carried Kodak products later added other competing lines of cameras and photographic materials. The top management of the sales department and George Eastman, not happy with creating a new sales network and then having other companies capture it, sought a solution to the problem. They adopted the general strategy employed by the unsuccessful plate and paper pool in the middle 1890s: the allowance of special discounts to dealers who abided by the terms of sale, such as those who sold Kodak products exclusively. At the turn of the century, as the Company placed more emphasis on manufacturing products that were not protected by patents, it extended its terms of sale to all Kodak products. If the dealer handled even one product that competed with Kodak, he would then lose the extra discount on the entire discount on the entire Eastman line. Eventually, Kodak created a chain of Company owned retail stores which shared any new development in film chemistry before anybody else.

All this was made possible by rather lenient Supreme Court interpretations of the Sherman Act, which did little to restrain entrepreneurs like Eastman who were skeptical of the validity of the legal restraints upon their consolidation efforts[22]. Furthermore, in 1899, when the Court, ruling in the Addyston Pipe Case, decided that it was illegal for a loose association of manufacturers to fix prices, it appeared that outright mergers into holding companies was the only refuge for industries that faced severe price competition. However, political and legal actions became more intense. The Court gradually began to shift its position as prices started to rise during the last years of the century and as journalists and the public became increasingly concerned with the social and economic implications of the new, giant corporations. In 1904, in the Northern Securities Case, the Court revived the moribund Sherman Act by ruling that holding companies were not automatically exempt from the federal antitrust laws. In 1903, in response to popular agitation, the Bureau of Corporations was established to compile data on corporate practices. Investigations conducted by the bureau provided data for the Justice

[22]In its rebuttal of Kodak's law suit against Fuji's alleged anti-competitive behavior in the Japan market, Fuji conceded: "The U.S. market has been shaped by Kodak's long history as the target of antitrust litigation, as both Kodak's competitors and the U.S. Government have at various times sued to stop Kodak's anticompetitive practices."

Department cases against Standard Oil, the American Tobacco Company and Du Pont. In 1911 these three corporations were commanded by judicial order to dissolve.

Consequently, in the 1890s and early 1900s Kodak came under attack from the government. for its horizontal integration activities. The Company's strategy shifted during 1911 to 1920 to vertical integration, moving backward into the production of many of its requisite materials. This strategy gave the Company increasing independence from the European cartels controlling many of the requisite supplies and also created major new sources of profit and operating economy. Because most of these supplies were not produced in the US, the Company did not acquire producing companies but sought instead to develop its own capacity for manufacture.

Also, by that time, Kodak had developed sufficient control over the film industry. The photography industry is one with many component industries within it and includes the cameras, film, print paper, developing chemicals, and developing machinery industries.. As Brock (1981) argues, the economic and technical dependencies in this industry make the functional location of the film industry very critical.

> "Functionally viewed, ... film is at the heart of the industry. For in traveling through a sequence of successive stages (from raw exposed film, to exposed but unprocessed film, to finished photography) ... film binds the industry's markets together ... A host of compatibility requirements is established as film percolates through the industry .. affecting the design of equipment, photofinishing services, and the chemicals, paper, and equipment required to process and print film. In short, the industry is functionally organized around the manufacture, exposure, processing, and printing of film" (Brock, 1981:17).

In 1904, Kodak held 90% of the market share in the amateur film trade. Indeed, through to 1976, Kodak's monopoly in film was uncontested. Film was the obligatory passage point for photography, which Kodak effectively controlled. The price of Kodak film included developing. . It was not until a 1954 decree forbade Kodak from tying film processing film sales. This led to various entrants in the photofinishing market. This decree was in response to concern that Kodak was using its market power in film to keep entrants out of the photofinishing industry by tying sales of film with photofinishing. However, Kodak's own Color Print and Process division (CP&P) controlled critical technical info on how best to photofinish Kodak film. The CP&P division could determine which photofinishers it chose to share this information with, and whether it would give them access to the best technology for photofinishing. Therefore, Kodak controlled the quality of services provided by its rivals in the photofinishing industry. This effectively kept big rivals out of the photofinishing market. Reduced competition in the photofinishing market was, of course, a source of profits to the Company. It also served to make the name "Kodak" synonymous with each step of the photographic film industry.

In addition, Kodak exploited the other connections in the photographic industry through its pricing policies for products used by rival firms. Kodak supplied key chemicals, as well as print paper, to rivals. Often, it charged these rivals "twice the price" than it did its internal CPP division. Moreover, these photofinishing rivals performed wholesaling activities for Kodak; that is, they redistributed Kodak film to retailers. Kodak did not give them any discounts for this, which meant that these photofinishers carried the cost of performing this function for Kodak, putting them at a cost disadvantage when competing with CPP. Once again, this meant market power in the photofinishing market, as well as the ability to price the processing fee for rival film products in a manner to make Kodak film purchase more attractive.

Another element of Kodak's exercise of market power was that its CPP division charged low prices in the relatively competitive photofinishing market, making up for lost profit by charging very high prices for film where Kodak enjoyed a near monopoly. In sum, photofinishers were extremely dependent on Kodak, a fact aided by the fragmented photofinishing industry that had no large, strong player.

Thus, Kodak did not only ensure the availability of cheap film, simple to use and reliable cameras, and photofinishing services, but also controlled all these activities, its dominance in the field being a near monopoly. . At the same time, Kodak almost single-handedly helped construct a society in which preserving memories as pictures and displaying them was a valued activity.

Table 4.1. Embodiment of Social Issues in Technology and Kodak's Role

Social Construct	Kodak's Social Strategy	Kodak's Technological Response
Class	Kodak took photography from the domain of the professional and amateur to the common man, introducing the Brownie for $1.00.	Mass production and compromise on quality brought prices down, putting photography within reach of the people. Daylight loading film, greater reliability and sensitivity of film, separation of development from photography all helped make photography the favorite pastime of America.
Family	Kodak positioned photography as an integral part of family occasions. Its advertisements showed how an ideal family looked, encouraging families all over to emulate this new ideal. Housewives were encouraged to preserve memories in albums.	In order to enable the housewife to take pictures, Kodak separated the complex development activity from photography. It made photography as simple as pushing a button. An elaborate network of dealers was established to ensure wide availability of film, development and other services. The introduction of daylight loading film eliminated the need for a darkroom. The addition of general stores to Kodak's network increased availability. The simple design was easy to manufacture for licensees, ensuring wide availability and addition of new stakeholders to the growing network.
Gender	The 'Kodak Girl' symbolized style, independence, and new gender roles , while preserving values such as feminine charm, attention to beauty and efficiency in housework.	Cameras were made lighter, simple to use and came in several colors. A 'Vanity' line of cameras was also introduced.
Children	Kodak regularly sent free cameras to children under the policy "plant a Brownie and the Kodak oak will grow." Popular symbols such as	The Cameras were made simple and special designs introduced for children.

	'brownies' were appropriated to infuse the technology with new meaning.	
War	Sending pictures home from the front and displaying them in living rooms were made part of mutual family responsibilities through advertisements.	"Autographic" cameras were introduced which began the trend to record dates and times with pictures.

CONCLUSION

The case of the roll-film camera provides several insights, which help us in addressing the research questions proposed in the first chapter. For instance, was roll-film technology inherently superior to dry-plates when it was introduced? The case clearly illustrates that had Eastman continued pitching the technology to the existing market, it would never have succeeded the ground. Why did Eastman Kodak leave an established, socially sanctioned, institutionalized technology (dry plates) and make a commitment to a technology languishing on the margins? Institutional theory has long faced a problem in explaining such major changes. If the use of a particular artifact or process has been socially sanctioned to be the most appropriate technique or manner in which to carry out a particular activity, how is change possible? Why would a legitimate player risk ostracization by the organizational field by pursuing a technique which does not have much legitimacy (functional reasons are of course not considered the primary motive for change within the institutional paradigm)? Two sources of change are often pointed out: powerful institutional entrepreneurs who have the capability of constructing or substantially modifying the existing institutional structure in an organizational field, or outsiders, who do not have the fear of losing legitimacy by engaging in an as-yet-illegitimate activity.

In the case of roll-film cameras, several institutional forces combined to lead Eastman along a different technological trajectory. First, the maturity of the dry plate market had initiated price wars, cutting profits. Second, while Eastman had an initial advantage in mass production of dry plates, this was being eroded because of large-scale diffusion of knowledge about mass production techniques throughout the industrial landscape. Moreover, several of his competitors held some important patents in emulsion making techniques, which were extremely specialized and harder to get around. Indeed, Eastman's dry plate sales were falling consistently. In fact, the Company survived because of its paper business. During 1886, nearly two thirds of its sales were either in printing or negative paper. Third, the consolidation of the dry plate industry had limited potential for growth and the traditional avenues such as acquisitions and formation of agreement pools were under increasing scrutiny from regulatory bodies. Fourth, Eastman's own outlook on the practice of photography was different from his competitors since he was the only non-professional photographer head of a major firm which made him by some standards, the least legitimate one). His attachment to technology was less emotional than that of his competitors, which made him the ideal institutional entrepreneur or the vehicle of change. Indeed, Eastman's lack of credentials made his socialization in the profession more superficial and perhaps that was what enabled him to break institutional moulds more easily, and keep attuned to the market. For these reasons, Eastman was the first one to pick up a new, as yet unsanctioned technology and introduce it in first, a structured institutional field, and later, in an unstructured one in the form of the mass market.

Path dependency theorists argue that it takes several 'random' events to generate initial acceptance for a technology. While based on qualitative and sparse data, it is not possible to systematically refute the 'random events' hypothesis, I do find it extremely difficult to dismiss Eastman Kodak's enormous campaign to generate acceptance for roll-film technology as a key reason for its eventual success. Indeed, the fact that roll-film initially failed, and then after Kodak re-positioned it with respect to markets and social institutions achieved dramatic success only adds more credibility to the claim that it was Kodak's strategy which underpinned roll-film's success rather than random events. However, this strategy was not limited to technology or economic markets, but was most evident in the social domain, often overlooked in studies of technology. In fact, without understanding the social dynamics, it is difficult to make sense of technological transformations.

By the early 1900s, the market for photography had changed drastically. For the new market, which primarily consisted of ordinary people, with little initiation in photography, the objectives and meaning of photography was quite different from only ten years ago. It was because of this transformation of the market and social meaning of photography that roll-film cameras could be termed as 'superior' to dry-plate technology. The achievement of this fundamental change in context, and consequently the evaluation criterion, was what Eastman Kodak had been striving for and represented its real success.

The final research question provided the best perspective on technology evolution. It was by exploring the connection between technology, issues and emergence of the institutional field that much was learned about how technologies evolve. Hoffman (1999) has argued that new fields are precipitated by disruptive events and emerge around issues that follow the disruptive change. Contrary to Hoffman's conclusions, I found that roll-film innovation was not in itself a disruptive event. Indeed, Warnerke had already developed the basic design and even when Kodak introduced it in the market, it failed to create any ripples in the market. Instead, the disruption was created by Kodak's efforts to popularize the design. By itself, the design was like a rugby ball sitting on the ground. It took monumental efforts from Kodak to develop a play around it. Issues of quality, complexity, availability, reliability and so on engulfed these efforts. Gradually, Kodak engaged in creation of new meaning around the activity of photography and transformed the technology so that it came to embody the new beliefs, interests and understandings. Thus, rather than forming around issues, the new institutional field was shaped by the interactive, structurational (Giddens, 1984) relationship between technology and issues which was mediated by the technology's sponsor, Kodak.

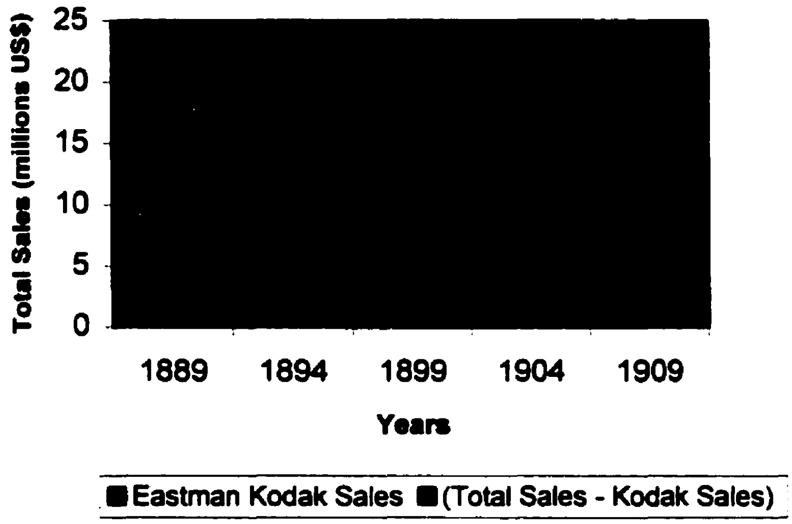
Determinist explanations of the roll-film camera's success credit the technological development undertaken by Eastman, which made photography simple and inexpensive enough to be undertaken by lay people (e.g., Tedlow, 1997). Frequently, Eastman's foresight and business acumen is emphasized in such studies, with special emphasis on the fact that he was the first one to see the enormous potential of the mass market. On the other hand, a more sociological explanation, requires looking beyond the narrow realm of technology and into the social processes that were transforming the market in which roll-film cameras prevailed over all other designs. Such a perspective, undertaken in this study, reveals a dynamic, rather than static, interaction between technology and market, with social forces as well as managerial agency mediating heavily.

Photographic technology cannot be evaluated in isolation from the social context in which it is embedded, and of which it is both a product and a cause. Indeed, distinguishing the 'technology' (cameras, film, other equipment) from the social institutions that provide the context in which the technology makes sense to us is not an easy task. Both evolve in sync, and influence each other's particular development. However, both are not the *only* influences on each other. Seemingly unrelated developments outside the institutional field can, and do have an equally profound influence on technological and social evolution. The is the formation of a 'technology system' which is based on a particular understanding of a central activity , in this case, photography, the most 'feasible' technology for carrying it out and a network of agents who support the technology as well as its prevailing 'meaning.' Kodak's achievement of dominance in photography was thus both a result of technological and social engineering. While several possibilities existed for 'technology systems' the peculiar combination of technology and its social definition that eventually emerged was the result of various forces. These include: a firm's strategies which is in turn a function of existing commitments or capabilities, network externalities, efficiency considerations or any number of social pressures; large-scale institutional changes or technological advancements within or without the institutional field; and government intervention. It is this interaction between social dynamics and technological solutions that Kodak successfully managed to its advantage.

Kodak successfully negotiated various currents that existed in its environment to position photography as a social, popular and essential activity. By actively positioning its technology strategically with respect to various emerging understandings of family life, gender relations, and social behavior in general, Kodak was able to infuse photography/the camera with specific meanings. - It became an everyday device that could (and should) be used both within and outside the home, by men or women, and which was (and should be) an essential companion on vacations, or any social occasion, adding 'fun' to the event and preserving memories. Parallel to, and in many ways integrated with, this process of socially defining photography, were Kodak's efforts to build a technological system which could 'enable' roll-film photography to be as simple as it claimed to be. Unless a network of agents were committed to the design, Kodak could not hope to deliver on the claims of simplicity, availability and technical superiority it had made to the users. In short, it needed to enroll the support of several agents, who could provide chemicals, various specialized parts, and manufacture and sell cameras and film. At the time, it was not very difficult for Kodak to build such a chain, since the majority of activities were carried out by itself. Kodak cameras came loaded with film and were returned to Kodak's dealers for development, who reloaded the camera. Kodak's strategy of taking over competitors and aggressively buying patents, aided by a nascent regulatory environment, helped it establish a monopolistic control over camera, film and processing businesses.

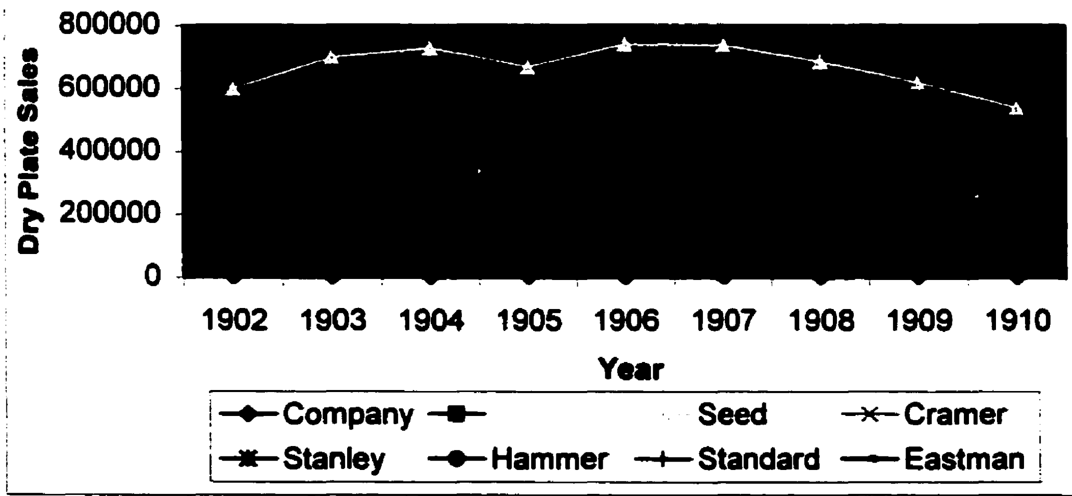
FIGURES TO CHAPTER 4

Figure 4.1: The Success of Roll Film and Kodak's Increasing Market Share



Sources: Data taken from Jenkins (1975)

Figure 4.2: Kodak's Declining Dry Plate Business



Source: Data taken from Jenkins (1975)

CHAPTER 5: CAN A FIRM BE TOO INNOVATIVE FOR ITS OWN GOOD? THE CASE OF POLAROID

In the previous chapter, I argued that the success of roll-film technology was due to Kodak's ability to redefine photography, thereby changing the evaluation criterion that people employed to judge photographic technology. Polaroid offers a study in contrast. Instead of socially defining photography around its unique and extremely popular technology, Polaroid focused almost exclusively on technological innovation, striving to improve the quality and efficiency of its Instant cameras while adding sophisticated and highly innovative new features to it. While this strategy appeared to work well in the initial years, it was suddenly rendered inadequate in face of competition from the 35mm format. In this chapter, I briefly describe first Polaroid's technological and commercial progress and then its demise. I then argue that the fall of Polaroid was not because of the availability of a better technology (35mm) or the minilab[23] (1 hour processing), but was a result of Polaroid's sole focus on technological advancement and its policy of keeping its technology proprietary. With such a strategy (which led Polaroid to have Kodak ejected from the Instant photography market) Polaroid managed to alienate members of the network that had formed around its technology (who went on to join the rival 35mm network). With its increasingly strong network, and propelled by bandwagon effects, it was only a matter of time before 35mm technology became dominant, relegating Polaroid to the ranks of could've beens.

A BRIEF HISTORY OF POLAROID

Polaroid was founded in 1933 by Edwin Land, a Harvard student who dropped out without finishing his degree. After dropping out, Land began a business in association

[23] Minilabs are automatic machines in which the roll is fed from one end, and photographs taken out from the other, in a few minutes.

with one of his professors. The fledgling company, known as Land-Wheelwright laboratories, produced polarizing material for no-glare car headlights and windshields. Enthusiasm for their work ran high, but commercial success eluded the Land-Wheelwright crew. Several attempts were made to woo carmakers in Detroit, but all were rebuffed. The company entered the Great Depression with no customers. In this critical time, incidentally, it was Kodak which provided the company's first financial break by placing a $10,000 order for photographic polarizing filters, later dubbed Polafilters. These plates, which consisted of a sheet of polarizing material sealed between two glass discs, increased contrast and decreased glare in photographs taken in bright light.

In 1937, Land formed Polaroid Corporation and acquired Land-Wheelwright laboratories. However, all the uses that Land devised for polarizing filters and its 3-D technology could not be made commercially viable and it was only the several lucrative government-military contracts awarded to Polaroid during WWII that saved the company from ruin. Undaunted by commercial failure, Land continued his research, and on February 21, 1947, demonstrated the first Instant camera publicly. After taking the picture, the camera instantly ejected the photograph, which developed within a minute. Polaroid made headlines nationwide and commercial success soon followed. First-year photographic sales exceeded $5 million and by 1950 more than four thousand dealers were selling Polaroid cameras, when only a year earlier Kodak had virtually monopolized the US photography market. Throughout the 1950s sales mounted, spurred on by an aggressive television advertising campaign which involved graphic demonstrations of the technology (Wensberg, 1987). Despite some initial problems with the functioning of the film[24], demand for Instant photography soared. Polaroid continued to offer improvements and variations on the original Model 95 Land camera and film, although other products were also introduced. Polaroid's first color film was introduced in 1963, along with a non-fading black-and-white film. In 1965, the inexpensive Swinger was pitched to teens. Selling for less than $20, the camera took only black-and-white pictures, sustaining the market for Polaroid's black and white film. The Swinger's primary competitor was

[24] The black-and-white images began to fade and disappear. Unable to develop a non-fading black and white film, Polaroid provided sponge-tipped tubes of a liquid polymer, which the consumers hand-applied to each picture to set the image. This awkward process was not eliminated until 1963.

Kodak's Instamatic, introduced in 1963, which eliminated roll-film in favor of a cartridge that dropped into the camera like a battery and further simplified photography for the masses.

In 1972, as Kodak took the tremendously successful Instamatic to new heights by introducing a pocket Instamatic, Polaroid introduced their third generation camera, the SX-70. This camera was dubbed the ultimate one-step mechanism for taking high quality pictures (acknowledged by experts to be perhaps the greatest innovation in the field of photography ever). The camera's highly innovative design broke away from traditional standards and required Polaroid to enhance several aspects of their manufacturing capability. Around 1976, Kodak introduced its own Instant photography system. Almost immediately, Polaroid sued, thus entering a costly and lengthy patent-infringement battle with Kodak. Polaroid won the lawsuit, and Kodak was asked to pull out of the Instant camera market completely and pay Polaroid $960 million in damages. By this time, however, the competitive environment in consumer photography had changed. Polaroid's problems with the SX-70 combined with Kodak's pull-out, as well as new competition from the Japanese who backed the 35mm format en masse, made 35mm a rapidly strengthening technological format. As bandwagon effects came into play, there were innovations in camera, film and developing/printing technology, which resulted in Instant photography - once considered as good as the reigning 110 format - being associated with fuzzy pictures. After the introduction of its most innovative product, Polaroid was besieged with problems from which it never really recovered (the origin and causes of which are relevant to our analysis and will be discussed in this case).

In many ways, Polaroid's fate was similar to that of Apple Computer Company. It was an extremely innovative company, which came up with a radical innovation, but could not manage to make it a part of our lives. Its technology remained a radical claim, which was supported by some, but never by most. Whereas a network of stakeholders had quickly formed around Polaroid's innovation, Polaroid's technology strategy served to weaken rather than strengthen it. Polaroid cared more about selling individual products rather than a lifestyle, which its core technology implied. The long-term success of Polaroid was never in doubt as far as analysts were concerned, but still never materialized (Wolfman, 1976). Polaroid was unable to position its technology so that it became a part of an expanding network of supporters and allies. It never opened the design so that others could embody their interests in it too. And finally, it never tried to alter the meaning of photography around the distinguishing features of its design. In the following paragraphs, I discuss how Polaroid's demise began with its most innovative product ever. Please note that although a section on Polaroid's initial success would be useful here, I have put it in Appendix 2 since the scope of this case is limited to the *failure* of Polaroid despite its innovative ability.

POLAROID'S CROWNING INNOVATION: THE SX-70

Polaroid enjoyed spectacular success in its initial years. Unlike Eastman Kodak, which had to completely change what photography meant to most people, Polaroid found the market ready and eager to try its new 'magic' camera. Polaroid's hundreds of patents combined with highly specialized knowledge, ensured that competition stayed out of this market. Financially, Polaroid had rich cash reserves and was widely considered one of the premier stocks to own. By the time Kodak entered the photographic market, Polaroid was synonymous with Instant photography, maintaining its monopolistic hold on this market until 1976 (by this time Polaroid had penetrated 50% of U.S. households). It was part of every stock analyst's recommended stocks and every photographic industry analyst's forecast for the future. Polaroid was expected to stay on and eventually dominate the market. (Wolfman, 1977)

Polaroid's strengthening position was attributed widely to its brilliant technological innovations and to the vision of its founder, Edwin Land (Wensberg, 1987; Olshaker, 1978). Indeed, Polaroid had pioneered completely new approaches to Instant photography twice by the 1970s (the original roll film, film packs (types 107, 108, 105 films)). However, by popular consensus, its crowning achievement was the SX-70 system. The SX-70 was a critical juncture in Polaroid's life because it was the most innovative design they ever produced (by popular consensus) and yet it was not the commercial success that it was expected to be. The design, production and marketing of SX-70 effectively reveals Polaroid's technological brilliance, innovative ability, strategic understanding of the market, and competitive strategy in the institutional field. At the same time, the SX-70 project marked the beginning of Polaroid's problems, so it is through this particular project that we will attempt to uncover the reasons for Polaroid's eventual demise.

Launched in 1972, the SX-70 completely obsoleted earlier technology (embodied in Polaroid's Colorpack camera). Olshaker argues that no one who had ever used a previous Polaroid roll or pack camera could deny that the SX-70, despite its longer development time, was a quantum leap in design. And anyone who was first introduced to Polaroid photography through the SX-70 and then tried to use any of the second generation cameras was probably staggered by how difficult it seemed by comparison, and how much more prone to human error. This was the first real one-step camera. The entire time elapsed between the pressing of the shutter button and the ejection of the picture card was slightly over 1 second in the SX-70. There was no mess and picture quality was as good as, if not better, than the competing 110mm from Kodak.

Rather than use the company's existing, successful $30 Colorpack camera as a starting point Land ordered his engineers to start from scratch on a totally new design. The design criteria for the SX-70 as outlined by Land, had been startling: it must fold to a size appropriate for a pocket or purse; be an SLR viewing and focusing design; focus from less than a foot to infinity; and be totally automatic (exposure, processing, and so forth) and litter-free (Merry, 1984). The photographer need only compose a picture and press a button. No other details should interfere with this process. As Polaroid's ads suggested, the photographic process was to be totally separated from the creative act. These philosophically ordained criteria created a number of practical problems for designers.[25]

> Land's ambitious design specs forced harried Polaroid chemists, engineers, and designers to invent entire new technologies from scratch, like automatic exposure (and, in later models, autofocusing via sonar), flat

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[25]Land made no compromises in its design. The reflex viewing system alone, for instance, cost millions: a single mirror, one of three in the camera, took over 2 ½ years of full-time computer work to engineer and the eye-piece design cost $2 million to develop. An engineer assigned to the camera design commented, "Land gave my boss a block of wood and told him that's how large the camera could be. He'd

batteries (every film pack contained a battery) and developer chemicals that functioned like clockwork and stopped working once the print was fully developed. Indeed, remarkable advances were being made in film technology. Olshaker (p.176) quotes Prof. Jerome Lettvin of MIT. The film, Lettvin argued, was "unbelievably brilliant":Land had to complete a set of about eighteen, interlocked, fusion-controlled processes. It required devising an ultra-thin layer of white with almost no ability to pass light. But then later on you had to be able to diffuse colors through it. And the pictures had to be able to develop even in bright light (an unprecedented requirement). Just that alone was a tour de force of enormous magnitude. A tremendous number of molecular processes have to start and stop by themselves. (Lettvin as quoted by Olshaker (1978: 176))

Prior to the invention of the transistor and its related circuitry, the electronic components needed to perform the automatic functions Land had in mind would not have fit into a large suitcase. Bell's telephone lab's perfection of the semiconductor represented a new generation of electronic miniaturization, leading to such breakthrough items as the pocket radio and portable TVs. Since then, miniaturaization had experienced a second generation of ultraminiature components. Solid circuits no larger than a word on this page could be produced containing literally thousands of transistors and other devices. The SX-70 system also took full advantage of the strides in micro-circuitry. The camera segment containing the lens and shutter button contained three incredibly complex miniature circuits, controlling the motor, flash mechanism, shutter, and electric eye, and coordinating each of the functions that took place in the second after the shutter button was pressed. The electronic model was initially made up on a circuit board about the size of a living room wall. This entire program was then reduced to the three chips contained in the SX-70 shutter housing by a process not dissimilar from photography. As a standard negative is enlarged to make a positive print, so a plan for the circuit was shrunk to its fingernail size and "printed" on tiny wafers of plastic. Texas Instruments,

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decided on that size by what would fit in his coat pocket. So in a sense, you could say that Land's tailor determined the size of the SX-70" (Olshaker, 1978: 173).

one of the pioneers in microchip development, designed the electronic module for the SX-70. Then there was the industrial design of the machine. The SX-70, with its angular lines, a viewfinder that evokes the subtended angles of vision itself, and its sci-fi metamorphosis, was considered a "charming, tangible embodiment of the dated futurism of the postwar American consumer era, which envisaged a 21st century of tidy suburban homes, ubiquitous electronics (and robots!), and at-all-angles Jetsons-like interiors" (Olshaker, 1978: pp).

Although the company never formally disclosed the cost of the SX-70 program, Land once referred to it in an interview as "a half-billion dollar investment" (Merry, 1984). Some outside estimates have placed the actual figure at much more than that. This is because it required the total integration of the company (a color negative manufacturing plant and camera assembly plant, and expansion of the firm's existing chemical production facilities and film packaging operation). It was not until January 1974 that the SX-70 was breaking even on a variable manufacturing cost basis. And it was only in early 1976 that most outside observers felt that the product was profitable in a conventional accounting sense (McElheny, 1998).

For Edwin Land, the SX-70 was the realization of a dream, not merely a new product. He often referred to it as "absolute one-step photography." As he stated in a booklet entitled "The SX-70 Experience":

> A new kind of relationship between people in groups is brought into being by SX-70 when the members of the group are photographing and being photographed and sharing the photographs: it turns out that buried within us –God knows beneath how many pregenital and Freudian and Calvinistic strata – there is a latent interest in each other; there is tenderness, curiosity, excitement, affection, companionability and humor; it turns out, in this cold world where man grows distant from man, and even lovers can reach each other only briefly, that we have a yen for a primordial competence, for a quiet good-humored delight in each other; we have a prehistoric tribal competence for a non-physical, non-

emotional, non-sexual satisfaction in being partners in the lonely exploration of a once empty planet." (Merry, 1984)

But the SX-70 represented more than a mere improvement in convenience and error-resistance. It was becoming, in a sense, a new "form" of still photography. A number of celebrated professional photographers had glowing things to say about SX-70. One of the most famous photographers of the time, Walker Evans told a group at Yale in 1974:

> I am feeling wildly with the SX-70. A few years ago I would have said that color is vulgar and should never be tried under any circumstances. It's a paradox that I'm now associated with it and in fact I intend to come out with it seriously. You photograph things that you wouldn't think of photographing before. I don't even know why, but I find that I'm quite rejuvenated by it." (quoted in Olshaker, 1978: 181)

Similarly, Ansel Adams, who had been using Polaroid film since it came out, called the SX-70:

> ...an absolute miracle. The film is very short-range and as long as the subject is also of short contrast range you can get absolutely magnificent color. It's sometimes difficult for professional photographers who are used to controlling wide ranges. But to the amateur it gives a tremendous, high level of response because they instinctively live in a world of an agreeable total contrast range." (quoted in Olshaker, 1978: 215)

Olshaker wrote:

> The fact was that the SX-70 was at its best with small, close scenes and that the picture actually developed in full view gave a sense of

intimacy between photographer and subject that has never before been possible. There was an undeniable kick in watching an image materialize before one's eyes. It was bound up in the whole concept of the creative process and in discovering how well one saw what he thought he saw. It was this sense of curiosity that Polaroid capitalized on.

For a number of technical reasons having to do with the dye-developer chemistry and the luminous backing layer, SX-70 photography also possesses an illusion of depth difficult to achieve in a two-dimensional medium. This alone makes it an advance over previous Polaroid color cameras. The unusual sense of depth can be difficult to get used to at first (it was for me) because it seems to violate a photographic convention we have become accustomed to. Photographs ought to be flat, it seems, and the SX-70 print somehow appears to take up more "space" than its several thousandths of an inch of thickness would indicate. Once mastered, however, the camera can yield fascinating new results, and familiar objects can be seen in unusual relationships to each other. And in this sense, the camera actually does enhance the user's vision and perceptual understanding of the world around him." (Olshaker, 1978: 230)

THE DECLINE OF POLAROID'S FORTUNES

It is ironic that Polaroid's downfall should start with the SX-70, a brilliant technology that reaffirmed Polaroid's position as the leading innovator in the industry. However, as Figure 5.1a and 5.1b show, Polaroid's problems started around the same time. While sales and market share of Instant cameras increased for a few years (especially after Eastman Kodak entered the Instant business in 1976), but the end of the 1970s, it was difficult for Polaroid to keep up with competition from 35mm cameras. Market share began a decline in late 1970s and never recovered. What were the dynamics that prevented the SX-70 from renewing Polaroid's fortunes? In the following paragraphs, I discuss aspects of Polaroid's strategy, which arguably contributed to its eventual failure. This discussion is carried out in two parts. First, I discuss how Polaroid 'understood' its own technology. This is crucial in developing an understanding of how Polaroid handled it and how Instant photography, despite gaining legitimacy, failed to become institutionalized as *the* way of taking photos as opposed to the traditional method. Secondly, I discuss Polaroid's policy of keeping technology proprietary and focusing on technological innovation regardless of the possibility that it might lead to alienation of key stakeholders.

Figure 5.1a & 5.1b About Here

Polaroid's Conceptualization of Technology

It must be remembered that Polaroid had chosen to introduce a technology which, in Kodak's opinion, could not be expected to have much of a future in the market. The mass market for Eastman Kodak was driven by a quest to produce images of sharp quality, as simply and cheaply as possible. Polaroid cameras were an innovative idea, but could it become the *dominant* way of taking pictures? The answer to this question, as we saw in the case of the roll-film camera, depended on how photography was understood, what characteristics were valued and associated with photography, and how Polaroid cameras fit into the institutionalized activities of everyday life.

Polaroid's (as well as Kodak's) understanding of why its technology had succeeded seemed a product of functionalist assumptions about photography. Indeed, whereas photography had become a social activity, and customers showed their great appreciation for Polaroid's technology that added life to their parties and other social occasions, Polaroid itself appeared to attribute its success to the sophistication of its technology. Land assumed and insisted that people would upgrade their cameras as they learned the art of photography and became comfortable with the technical aspects of high-end cameras. In an interview with *Forbes* in 1975, Land said:

> My basic faith is in the random competence of people in all walks of life, at any level of income, of any derivation. There is a common sense

of beauty and of manual aptitudes… I believe that this camera and what it does will be a necessity to everyone, once they learn how to use it." (*Forbes*, 1975)

Accordingly, Polaroid had developed its own routines which de-emphasized (actually shunned) market research and focused on technological brilliance. As I discussed in the last chapter, photography had made its mark as a legitimate activity, distinct from painting, on the basis of its ability to capture images accurately[26]. It was widely understood that this was indeed what people wanted: accurate representation of objects (Polaroid sought to provide the same albeit without the delay of developing). The fact that people had found Kodak's roll-film technology - which produced images of much inferior quality (compared to dry-plates) - enormously appealing, had little effect on this perception. Indeed, very soon, Kodak itself was touting its increasingly better quality as a differentiating feature. Apart from quality, price, size and other features (electronic shutter, autofocus etc) were the evaluation criteria, popularly perceived to be influential in purchase decisions. When a camera sold well, it was automatically assumed that it was because people liked its performance/price ratio (picture quality, size, and sophistication was worth the price). Thus, the Wolfman report noted in 1978:

> The amateur photography market continues to move simultaneously in two directions. At one end, enthusiastic amateurs demand more and more sophistication and precision in their equipment, with ever-increasing esoteric capabilities. At the other end, the average casual picture-taker wants the lightest, simplest, most foolproof device for recording where he has been, who else was there, and what color it all was. It is this second trend that has sold tens of millions of Kodak Instamatics, and it is this trend that Polaroid has been trying to lock into since 1949. With the SX-70, Land was trying to take advantage of both trends" (Wolfman Report, 1978).

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[26] Johnson (1999) has emphasized that "absolute material accuracy" was seen as the hallmark of photography in late 19th century.

Naturally then, all design and manufacture of photography equipment was geared towards improving the quality of photographs, reducing the size of cameras and packing in as many sophisticated features as possible for the minimum possible price. Thus, it is no surprise that when Edwin Land approached Kodak with his design for Instant photography, Kodak was not interested. The photo quality was poor, the procedure for developing photos messy and above all, given the conclusions of current market research, Kodak could not see much scope for this product in the market.

Since Land never conducted any market research, it is not possible to say if the market itself would have shown interested in such a product. Given the common tendency to calculate performance/price ratios based on existing evaluation criteria, we could accept Kodak's decision to not pursue this technology as a proxy for the market. The important thing is that all forecasts regarding the eventual success or failure of a technology were made on the basis of technological features: quality of the outcome (photography) and the features included in the camera. That the real difference between roll-film and Instant technologies lay in how they interacted with existing institutions and in their associations with an altogether different definition of photography was not discussed, even if it was realized. Indeed, Kodak only considered Polaroid cameras a threat when they encroached its price category. When Polaroid brought out the $14 Swinger in 1965 (Polaroid's first camera to sell for less than $50), Kodak immediately saw it as a major threat, for it signified that Polaroid could effectively compete in the inexpensive mass end of the market, which had been Kodak's bread and better. This is a great illustration of how technologies and their interaction with users' lives were perceived at the firm level.

This is not to say that quality did not matter. Indeed, as the general level of technology advanced in the industry, and the roll-film camera produced images of increasingly better quality, users' expectations of image quality also went up However, quality had a distinctively different meaning in the domain of professionals who dominated most photographic organizations. These actors shared a culture in which photography was still driven by a desire to capture images as accurately as possible (all colors were represented realistically, including skin tones; motion was captured perfectly;

instruments notified you whenever anything was out of order; cameras allowed photographers to be creative by providing control over several features; etc.). The idea of Instant photography was rejected by Kodak on all these grounds. Not surprisingly, Eastman Kodak was duly surprised at Polaroid's spectacular success in the market. Still Kodak's cameras were cheaper and produced better quality images, a fact that provided them with much needed confidence.

Polaroid's views were reinforced by popular opinion in the industry. For instance, when asked about the possibility of Kodak's Instant cameras cannibalizing its traditional mainstay, Gerald B. Zornow, President of Kodak said:

> Our view is that this is not an either-or situation. Its another one of those cases of two ways of doing something with each having benefits to offer for different people and different occasions. *Conventional methods will continue to be used when the highest possible quality results are wanted, for multiple prints and enlargements, and certainly when there is a sequence of events to be captured.*"[27] (Wolfman Report, 1969-71) [italics added for emphasis]

Apparently Zornow forgot that dry plate manufacturers had made the same argument eighty years ago, but Kodak's roll-film technology had managed to build a market for itself where portability and ease of use were desired over extremely high quality. Polaroid could, likewise, conceivably try to define photography in a way that the Instant feature became a 'must' for any kind of photography. However, instead of developing its strategy on the basis of its primary difference - the instant gratification it provided - Polaroid chose to differentiate itself from Kodak on the basis of quality of image and technical sophistication of cameras. Instant imaging could very well redefine photography, just as roll-film had redefined it fifty years ago. However, whereas Kodak's efforts had been geared towards changing the fundamental understanding of photography

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[27] Zornow's statement reflects how Kodak understood the market. Photography was understood to be carried out solely on a functional basis, instead of a social one. Thus, Kodak (after Eastman) and Polaroid both understood the market in functional, technological terms.

in society, Polaroid directed its efforts at meeting existing, already defined expectations through its novel technology. Thus, rather than encouraging a novel institutional framework to develop around Instant photography, it sought to position Instant photography within the existing institutional framework. The Instant imaging idea coincided with dominant trends in material consumption appealing tremendously to the public. However, while it was a legitimate method of photography, it was not obviously the best way. In order for photography to become culturally institutionalized as an activity where there must not be a lag between picture taking and viewing the photo, the definition had to be supported and shared across the entire field, as well as by the general population. Polaroid did not put enough effort in to framing photography in terms of Instant imaging to bring about the necessary change.

For Polaroid, job number one was to provide a state-of-the-art technological tool with which people could pursue their need for photography. It was less a focus on creating and shaping this need so that only Instant photography could satisfy it and more on providing technically advanced cameras, where advanced was understood in criteria that were common to all formats: quality, size, price and reliability. Thus Polaroid was competing on technological merit and existing definitions of price/performance rather than emphasizing the starkly different lifestyle that Instant photography implied.

Indeed, by the time Polaroid introduced the highly advanced SX-70, consumers were familiar with the workings of Instant cameras, and routines were beginning to form around their use. Instant photography, in other words, was in the process of being institutionally defined. Instant cameras were fun and were becoming part of social occasions just as food and beverages have. With these cameras the range of one's photographs increased considerably (i.e., one could photograph friends or acquaintances in poses or situations which would not be possible if a third party was responsible for developing those images). A look at any random sample of Polaroid pictures taken during the early 50s provides evidence for Land's claim that his product helped people better relate to each other. In any group of these snapshots, one seldom finds more than two or three scenes or landscapes: nearly all the prints are of people, generally in small groups, and usually including children (Bourdieu, 1996).

Contrary to popular belief, and even Land's own understanding, Land's cameras were valued as a cultural artifact rather than for their technological prowess. Indeed, even when the process of taking pictures involved applying chemicals to the freshly developed photos (the pictures would fade away unless users applied a messy chemical to them right after taking them out) their popularity soared. Similarly, much to Kodak's amazement, customers did not find the rather low reliability of Polaroid cameras annoying. (The same object captured by 50 different cameras would yield 50 slightly different photos. In other words, if you knew exactly how you wanted a photo to come out, several times you would be disappointed.) Similarly, the inability of even the most advanced Polaroid camera - the SX-70 - to function well in low-light situations, or the extra difficulty involved in getting duplicates or enlargements later on, failed to discourage customers.

Polaroid used a starkly different sense-making framework for understanding cameras than consumers. From Polaroid's perspective, it was already a fact that a camera was an accessory that had to be possessed by all. Indeed, when the SX-70 was about to be launched, Land criticized those who were quibbling about the fact that it may be priced too high. He scoffed at those critical of the selling price, seeing it himself in terms of human enjoyment and in light of the other things an average consumer spends money on. "We're trying to get $600 worth of camera to market in the $100 range." In a 1975 interview with Subrata Chakravarty of *Forbes*, he said:

> It isn't much money. Consider what you get. When you are buying a car and the dealer asks if you'd like an AM/FM radio or an extra speaker, each of those random trivia costs more than our whole camera does. It is a terrific buy." (Chakravarty, 1975:48)

Polaroid's belief was that products create markets, completely ignoring the possibility that normative or cognitive institutions may provide constraints on the consumers' behavior, thereby influencing consumers' choices. That completely new technology would necessitate the existence of new sensemaking frames (institutions) did not seem to bother Land. His conviction in technology's ability to attract people whose needs it meets led him towards the terrific financial plunge of developing the SX-70's, despite abounding outside skepticism. He maintained this faith during knee-buckling research and production delays. So it was with some degree of self and group satisfaction that Land could announce at the 1974 annual meeting, "The SX seems to be defying conventional marketing presuppositions, as we planned that it should." (Chakravarty, 1975)

Polaroid's advertising reflected this paradox (talking about a lifestyle but not differentiating it from the lifestyle implied by the other technological alternative). During the 1970s, most of Polaroid's ads in publications like Life emphasized the happiness and merry-making associated with Polaroid cameras, the range of low prices and savings that it provided, the instant gratification and superior technological features. It was also depicted as the ideal Christmas present, but the theme that ran through most advertisements was price. It was understandable that price was an important issue especially since the Instamatic and then the Pocket Instamatic from Kodak, two cheap and simple cameras, were capturing the imagination of the entire nation. However, it is also true that by emphasizing price instead of the different lifestyle that Polaroid offered, Polaroid was playing on Kodak's turf[28].

Polaroid's Technology Strategy

It is important to remember that when the SX-70 was introduced, Instant imaging was a legitimate and widely accepted technology. Indeed, Instant imaging was considered a major growth area and an evolving technology, especially since it was clear now (in 1972) that Kodak was about to join the race. The Wolfman report concluded in 1974:

> It is becoming more apparent that the trend toward miniaturization and increased automation will continue, particularly as advanced technology becomes available from such related areas as space and electronics. The ready acceptance of both the Kodak 110 system and the Polaroid Land system indicate that the two basic ideas of modern

[28] Since in Kodak's case, developing was separate from the camera, Polaroid was hard pressed to match its prices.

photography – the camera as a constant, always ready tool plus the elimination of the time lag between the conception of a photography, the making of the photography, and the final result – are valid approaches. (The Wolfman Report, 1974)

Wolfman predicted:

The long-term result should be a camera about the size of the 110 camera which will offer the Instant picture ability of the Polaroid SX-70 system. Add to this package virtually automatic operation and the durability and reliability of solid-state electronics and the net result should be a tremendous broadening of the market. (The Wolfman Report, 1974)

Two years later, the 1976/77 Wolfman report stated:

"... by and large, Kodak has been taking its chances with accusations of market dominance, and has tried its best to establish a foothold in Polaroid's specialty, *which may be the eventual primary trend in still photography.*" [italics added for emphasis]

And of Polaroid's double digit growth rate, Wolman predicted:

This growth rate shows no signs of abating and most industry observers agree that within a relatively short time, about half of the picture-taking dollars spent in the US will be spent on Instant photography. Despite the fact that Instant photography celebrated its 30th anniversary in 1977, the excitement created by this area of photography has never slackened. The reasons are the appeal of the medium itself plus a continuing flow of new products to expand the usefulness of the Instant process...Instant photography will continue to be the fastest growing segment of the photo market, not only in the US but in the very near future, throughout the world. (The Wolfman Report, 1974).

However, that did not turn out to be the case. In 1976, Walter Fallon, President of Kodak, reported that some 25 million Pocket Instamatic cameras had been sold by Kodak since the introduction of this format in 1972 (an average of 4.2 million a year). By early spring of 1976, there were about 60 different 110 models on the market, with prices ranging from $28 to $155. In contrast, only 2 million SX-70s had been sold by then ($180). There were, however, at least four other cheaper SX-70 models that had been introduced to spur sluggish sales of the SX-70. These included SX-70 Model 2 (1974-77: $149.95), SX-70 Model 3 (1975-78: $ 99.95), OneStep (1977-79: $ 39.95), and the Pronto! (1976-77: $66.00). The cheaper Polaroid models were doing much better than the expensive SX-70 (whose production was still causing major difficulties for Polaroid). About 25 million Colorpack cameras (which was Polaroid's leading seller before they introduced the SX-70) for instance, were in use by April 1976. As a result of ongoing production problems with the SX-70 (combined with a recession in the consumer market), Polaroid's profits took a plunge of almost 50% in 1974 (Figure 5.2).

Figure 5.2 About Here

Table 5.1: Instant Camera Models

(Only selected models are listed. Each model was followed by cheaper versions)

Polaroid Model	Year Introduced	Kodak Model
Swinger ($19.99)	1965	In 1963 the Instamatic had been introduced (126mm)
	1966	
	1967	
Big Swinger ($25)	1968	
Colorpack ($30)	1969	
	1970	
	1971	
SX-70 ($180)	1972	Pocket Instamatic (110mm)
	1973	
SX-70 Model II ($140)	1974	
Supershooter ($45)	1975	

Pronto! ($66)	1976	EK 4 & EK 6 Instant Cameras
OneStep ($40)	1977	
Presto	1978	
	1979	
	1980	
	1981	
	1982	Disc Cameras
	1983	
	1984	
	1985	
Spectra ($250)	1986	
	1987	35mm Cameras
	1988	
	1989	
	1990	

Sources: *Wolfman Reports*; *Olshaker, 1978; Wensberg, 1987*

On the other hand, Kodak had managed to sell more than 5 million pocket Instamatics (110mm) during 1975 alone (about 40% of the total cameras sold in the consumer market). Still, Polaroid's problems were thought to be production related and not a product of some weakness in the Instant format itself. Indeed during 1974, over a billion Instant photographs had been made and the Polaroid SX-70 system, despite its continuing production hiccups, had become firmly established as a reliable, viable system (although mainly due to the later, cheaper models).

The future outlook, according to Wolfman Report in 1976, was as follows:

> Presently, two areas show the most promise in terms of market expansion and product development: 110 format and Instant photography. The trend toward incorporating more sophisticated features in 110 cameras will continue, bringing to the 110 user such advances as single-lens reflex viewing, interchangeable lenses and built-in zoom lenses. The pattern in 110 will be for growth by taking a product originally meant for the casual user and developing it until it becomes a professional quality item. The expansion in the Instant photography market will be the result of new firms entering this market. One expansion, through the creation of a

whole new system of Instant photography, will take place when Kodak announces its system. (Wolfman Report, 1976)

It was considered inevitable by several analysts (e.g., Wolfman Report), that highly popular Instant gratification technology that belonged to Polaroid become part of every camera! Its penetration was growing every day. The introduction of Pronto! in 1976 only enhanced this trend. This was basically a Model IV SX-70: A nonfolding, nonreflex, molded plastic body camera with suggested list price of $66. Widely discounted by retailers to $49 (only a few dollars over cost), and by April 1976 sales and advance orders of Pronto! had exceeded 400,000 units[29]. Despite its almost fifty percent penetration of U.S. households, Instant photography was however, still only an alternative, not the only option. Arguably, Kodak, with its ubiquitous market presence would have been the ideal candidate to carry it to dominance. However, Polaroid's technology was protected closely through patents, which the company was not about to let Kodak impinge on. Rather, as soon as Kodak entered the Instant imaging field, consequently increasing total Instant camera sales by almost 45% (Figure 5.3), Polaroid sued it for infringement of its patents. After successfully driving Kodak out of the market in 1986 (in 1990 Polaroid was awarded $910 million in damages), Polaroid continued with its strategy of strict proprietary control over technology. However, an in-depth look into Polaroid's actions around the design, production and marketing of the SX-70 reveals other facets of Polaroid's strategy (deliberate or emergent), which were important determinants of Polaroid's eventual demise.

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[29]The price of supershooter was less than half that of Pronto but a supershooter print cost about 25% more. Pictures made from Polacolor II film was believed to have 'better' quality than SX-70 film, rivaling conventional color prints in resolution. Finally, Pronto! offered far simpler camera operation. The user just focused and pressed a button, and the camera ejected the print, which developed automatically in about 12 minutes with no litter. The Supershooter user, on the other hand, had to pull each exposure from the camera, time the development for 60 seconds, and then dispose of the used negative (which was rather messy). In terms of manufacturing processes, the two film types were similar, in that both required a negative, a processing reagent and print material. Each SX-70 pack however, also required a battery to power the camera's flash, exposure, and print ejection motor. The Pronto was essentially a Supershooter with a mirror and an electric motor added.

Figure 5.3 About Here

With the Colorpack, Supershooter and the various versions of SX-70 firmly in place, Polaroid was in a strong position by any definition of competitiveness and analysts widely agreed on its brilliant future. However, its overall competitive strategy, reflected in its disdain for market studies, overriding efforts to meet absolute technological standards, licensing policy, penchant for control and advertisements, combined with a changing environment, ensured that a network did not form around Polaroid's highly innovative technology, which ultimately served to de-legitimize it. In the rest of this section, I discuss how Polaroid undercut its own strengths by: 1) focusing solely on technology; 2) keeping its technology entirely proprietary; and 3) not recognizing the importance of several stakeholders such as photofinishers and Wall street in the pursuit of dominance. Finally, I briefly describe how the 35mm format, based on an open architecture, was increasingly becoming stronger by attracting all these stakeholders.

Market Studies and Technology Strategy

> Don't try something unless it is manifestly important and nearly impossible.
>
> --Edwin Land

This was the central belief around which Polaroid was formed and groomed. Consumer markets, maintained Land, should be created around inventions generated by scientific research, and not the other way around. At Polaroid, a deliberate effort was made to keep all technological development isolated from market research. Indeed, it was believed and preached, at least by top management, that the product sold itself, and by that logic, there was little use for market research (Olshaker, 1978; Wensberg, 1987). Naturally, while this strategy was eminently useful in developing radical innovations, it also eroded the chances of actually entrenching a great technology in people's everyday lives.

Such was Edwin Land's disdain for focus groups, marketing surveys and the like that his employees did not even dare to suggest such things to him. Polaroid comprised a small group of scientist-engineers who came up with 'dreams,' and then saw to it that those dreams were shared with the public. This was in stark contrast with Kodak's calm, corporate environment where no move was made without all the facts and figures. Since before Eastman's death, Kodak had been run by professional managers rather than free-spirited scientists. Although outwardly different there were always similarities between the two companies. Neither was unionized, and both were somewhat paternalistic, in a non-pejorative sense, towards employees. Both were financially conservative, and neither went to the money market for capital, preferring to finance from within. Indeed, it was the difference in their conceptualization of the customer-technology relationship which led to the vast differences in the way in which technology was acquired and deployed in the respective firms.

Polaroid thrived on invention combined with aggressive marketing to inform the consumers about the superior product they had created. As a result of its deliberately created isolation from the social trends around them, Polaroid's technology strategy was driven by absolute ideals, which, for Polaroid, all came together in the SX-70. The reviews that the SX received were exceptional and the SX-70 was, and still is, widely considered an icon of industrial design. While the SX-70's performance in the market left much to be desired (it was nowhere near expectations), it was instrumental in establishing Polaroid's immense technological brilliance yet again.

Naturally, Land's disdainful attitude towards market studies was reinforced by the spectacular success with which Polaroid's early products met. Polaroid introduced the First Land camera in 1949 in Miami[30]. On the first day the camera was offered, demonstrators sold all 56 of the available units, and the cameras kept selling as fast as the factory could produce them, despite initial problems. The pictures would quickly fade away unless users applied a messy chemical to them right after taking them out. Still, sales soared. First-year photographic sales exceeded $5 million. By 1950 more than four

[30] The logic behind the selection of Miami was that since a good percentage of the people in Miami at any given time were vacationers with a fair amount of pocket money on hand, they would provide a receptive market for a new luxury item. And of course the fact that they were travelers was of at least equal significance, since they could be expected to be taking a lot of pictures and when they returned home, would rapidly spread interest in the camera to all parts of the country. In that way, each community would be "seeded" with cameras to build up anticipation for the time when the product could finally be distributed on a national basis.

thousand dealers sold Polaroid cameras, when only a year earlier Kodak had virtually monopolized the US photography market.

Whether Polaroid realized it or not, its disdain for market studies and consumer feedback worked with the initial radical innovation. Indeed, Land had initially taken the Polaroid idea to Kodak, who with their ears glued to the existing market, dismissed it as an innovative idea but with little potential in the market. Land pressed ahead and introduced the first Land camera, a radically new technology, without any market research. Polaroid's approach was entirely intuitive, in keeping with Land's personality. "Industry must have an insight into what are the deep needs of people that they don't know they have." Market research, Polaroid felt, was only valid as a method of delineating an existing market, which in most cases has little relevance to what the company is trying to do. Indeed, according to the traditional method of market analysis, Polaroid's most innovative camera, the SX-70, could not possibly have sold in numbers sufficient to cover Polaroid's expenses, much less make a profit. The logic would have gone something like this: in 1969 – the peak year for camera sales in the US – 14 million cameras were sold. Only 1.7 million of these sold for $50 or more, and of those, about 800,000 cost more than $100. About half of this figure was taken up by 35mm sales. So the conventional wisdom held that even in an exceptionally strong year, Polaroid had a market for only about 0.4 million to work with if it expected to sell the camera for over $100. By this logic, Polaroid would never have entered the fray in the first place, let alone sell 5.5 million Instant cameras in 1976. With a price tag of $180, the SX-70 alone sold about 0.5 million units in its first year of sale, 1973.

Even when the technology was not radical any more, Polaroid continued ignoring market research. Marketing was specifically forbidden from doing any exploratory, inductive studies. If they felt they had a problem, in keeping with Land's dictates, they had to be able to state it. Polaroid had traditionally considered market research something to be done by companies without exciting products to sell. However, when the black and white Zip model was not generating any tremendous wave of enthusiasm among adolescents, it was finally decided to commission a survey by Trendex Corporation to find out exactly what those adolescents were looking for in a camera. The survey turned up the not-surprising fact, among others, that about 85% of them wanted color. Such was the length of the gap between consumers and the context in which these consumer-friendly technologies were developed.

Alienation through Innovative Product Design

Designing and manufacturing the SX-70 involved several hundred decisions, all of which impacted not only the final shape of the product, but also the competitive position of Polaroid. However, while the former relationship was easier to discern, the latter was more difficult to fathom. That is, driven by the overriding goal of producing the ultimate one-step photography system, it was assumed by Polaroid that the result could only be positive for them if they were successful. Thus, regardless of what may be called network considerations they pressed ahead and completely deviated from existing technological platforms and standards, making even their own existing technological products obsolete.In this section, I discuss how Polaroid's product design impacted their competitive position.

Land stated that the SX-70 would change the course of photography. Before that could occur, though, it set off a more immediate change: it changed the course of the company. Prior to the decision to manufacture color negative, Polaroid was essentially a high-technology "ideas" company. Principal camera manufacturing was farmed out, mostly to U.S. Time and Bell &Howell. Color negatives were produced by Kodak. Polaroid itself handled sheet and pod production operations and some of the final assembly. In 1969, Polaroid and Kodak signed a supply agreement that would have Kodak continue to produce the color negative for an additional 5 years. Polaroid needed the supply, and also theorized that keeping Kodak on board in this fashion might prevent it from trying to break into the Instant picture market with its own line. The 1969 agreement offered a further concession to Kodak. As of 1976, it would be allowed to sell color film packs for Polaroid Land cameras under its own name. With the SX-70, the beginning of Polaroid's third generation of cameras, Land and his associates decided that they should move toward becoming a vertically integrated company, which would not only come up with its own ideas but see them through to production on its own premises. This move would not only afford greater control, it would also mean greater profits.

Kodak's pretax profit on color film was 70 percent. Polaroid's finance department dreamed of approaching that figure with their own product (Olshaker, 1978).

Negatives: Despite occasional ups and downs, Polaroid's competence was never in question. Indeed, Polaroid had proved time and again, that it was probably the most innovative company on the block. Take the case of the color-negative material for SX-70 film. Previous Polaroid color negative had been turned out by Kodak, with years of experience under its belt. Photographic color-negative production is an extremely complex and technical undertaking. Even Dupont, a giant in chemicals, tried it once and gave up. So it was a particularly daring move when Land announced that Polaroid would no longer depend on Kodak, but would produce its own color negative for SX-70. Polaroid had a small pilot program in color-negative production going at the Waltham plant, and the results had been reasonably satisfactory. But producing the material in vast quantities with the high quality-control standards needed was still an uncertainty. And Kodak, for its part, had never allowed Polaroid personnel into its negative-producing plants in Rochester, so even the specifics of how past Polaroid negative had been manufactured were sketchy. When the film finally came out, it impressed even the most skeptical observers and reaffirmed everyone's faith in the Polaroid's inherent creativity. At the same time, however, Polaroid's strategy of vertical integration cut off relations with Kodak and several other agents that were involved in supplying negatives, thus leaving them free to join other technology or firm-centered networks.

In fact, in anticipation of such a move from Polaroid, Kodak engineers in Rochester, England, and France had been working on their own version of Instant photography for at least two years. Polaroid's decision to produce its own color negative almost forced them into it. From Polaroid's perspectivenot only did Kodak stand to lose the $50 million a year Polaroid had been paying them, but by cutting out the vendor payments, Polaroid would eventually be able to lower its own costs on film to the point where it could either cut retail prices enough to give Kodak even more competition in the mass market. Or by leaving prices as they were, they could squeeze enough additional profit out of film sales to afford more extensive marketing efforts. Either way, to hold onto its own share of the conventional market, Kodak had to give Polaroid a run for its money in the Instant field. As Kodak's new president, Walter Fallon put it, "we are unwilling to divert further effort and funds from the development of our own Instant system into a secondary and more limited marketing opportunity" (Olshaker, 1978). In stark contrast to Polaroid's strategy of planned obsolescence for earlier technology in favor of completely new designs, Kodak chose to continue with its popular Instamatic, but making it simpler and smaller. The result was the Pocket Instamatic designed to compete with the SX and plans to introduce a completely new system, the disc. Thus, the radically new design of SX-70 not only led to the break-up of Polaroid's network but also gave birth to formidable, new competitors.

Battery Design. Battery design for SX-70 is a particularly revealing example of Polaroid's strategy of innovation at all costs. Indeed, the SX-70's design was so innovative that not only did it prove to be beyond the ability of most players to manufacture it, but also deprived Polaroid from the obvious benefits associated with incorporating an established, institutionalized technology to serve the purpose. Polaroid had decided that for their new camera, the user must not have to worry about the instrument's power source. Dead batteries, causing non-function of electric-eye shutters, were traditionally one of the primary causes of bad photographs. And since not only the SX-70's shutter but its mirrors, film-advance system, and flash sequencer were all electronically controlled, a battery failure would be devastating. Also, nothing makes a camera enthusiast lose that enthusiasm as instantly as a Land picture develops as being all set to take a picture, having three or four packs of film ready and having the battery conk out in the middle of the Grand Canyon.

As Olshaker describes:

> The solution to Land was clear. To prevent all of this, the battery must be in the film pack itself, which means a fresh power supply would be introduced after every 10 pictures. The way to go about it was not so obvious. Again Edwin Land started with the requirements, with the idea of inventing something to fill them. The battery would have to supply 6 volts of power at intervals of less than 2 seconds over a possible temperature range of nearly 100 degrees. And to fit into the film pack, it would have to be nearly flat." (Olshaker, 1978: 212)

By 1968 these details had all been worked out, and Polaroid went with them to a number of battery manufacturers, and contracted the primary development out to ESB, Inc. of Philadelphia. The battery project faced enormous challenges right from the beginning. The 19 layers of metal and plastic had to be bound and sealed to extremely small tolerances, and in incredible quantities. No one had any experience in this type of battery production. Leakage became a sizeable problem. But an even larger problem was that the batteries had an unpredictable effective life, sometimes as short as a couple of months. So by the time a battery was manufactured, shipped to Polaroid, inserted in the film pack, and the film pack shipped to the retailer and eventually sold to a customer, there was often very little time during which it could be used before the battery would be dead. In the first several months of the SX-70's distribution, film pack returns caused by dead batteries were staggering (Figure 5.2 shows how profits dipped in 1973 because of dead batteries).

There had been extended discussion within Polaroid's upper R&D levels about scrapping the idea of integrating the battery with the film pack in favor of the normal battery in the camera. But Land was adamant that the SX-70 user should not have to replace his own batteries (Olshaker, 1978). This added one more complication to a project that already had attached to it a nearly limitless set of both requirements and variables.

Most battery manufacturers were unable to manufacture such a radical design, and Polaroid found itself unexpectedly – and at first, unwillingly – in the battery business. "We didn't intend to," Polaroid's president Bill McCune declared shortly after the move was made. "We've been backed into it." (Olshaker, 1978) Battery design and production, most experts seemed to agree, was as much an art as a science, with fewer guarantees than most of the scientific disciplines. So the initial results did not always coincide with anticipated ones. And the flat, several-chambered battery needed for the SX-70 film pack was a revolutionary design, which no one had much experience with. ESB and the other suppliers were unable to stop chemical leakage from one chamber to another or to find the right combination of materials to assure charge retention for a period of longer than a few months. Months of trial and error, both with new materials and manufacturing techniques, plus an accumulation of new knowledge, eventually led to the design of a battery that remained active for up to 18 months[31]. By the late 1970s, Polaroid was, by volume, one of the largest battery producers in the country strictly on the basis of the flat Polapulse battery.

Shutter Design. For much of the SX-70 development, the shutter mechanism presented an equally arduous challenge. Unlike previous Land cameras, the SX-70 was designed to combine electronic control of shutter speed (the time during which the film is actually exposed) and aperture (how wide the lens is opened, which determines how much light is allowed in). This was a complex problem, even with the advances in electronic miniaturization.

Two firms, Fairchild Camera and Texas Instruments, had been contracted to produce the electronic shutter module, with Fairchild supplying all of the initial units and TI scheduled to begin work with its own design several months later. The designers at Fairchild Camera, the contractors for cameras, were unsure that an integrated circuit of the sophistication required could be economically produced for the space allotted to it in the camera design. The way the operational amplifier - which ran the shutter - was formed sent the costs soaring. At one point Polaroid was paying its vendors between $25 and $30 apiece for the shutter components alone. With that kind of cost factor and bad starts plaguing the other areas of development and production, turning a profit would have been almost out of the question.

After Fairchild was unable to come up with a cheaper or more efficient way of layer-forming the resistors involved in the operational amplifier, Polaroid and Fairchild broke off their agreement and all of the shutter work reverted to TI. The shutter module

[31] The wafer-thin battery had some interesting features of its own. In addition to fitting into the SX-70 film pack, it provided large surface areas and short pathways, permitting current to be drawn very rapidly in a high-demand situation like the camera operation. Polaroid had disclosed the number of functions that could be performed by the flat battery in addition to the camera operation involved in taking 10 pictures, with or without flash. Automatic focus using ultrasonic echo ranging in the new family of SX-70 cameras, the Sonar One-Step series, was powered entirely by the battery. The battery itself could be further utilized once the film had been used. One patent described a slim flashlight powered by the 'empty' film pack and enterprising people explored such applications of the battery as the operation of electric trains. Two of the 6V batteries connected in series were shown to be capable of booster-starting an automobile that had a near-dead standard 12 V battery. Polaroid did not, however, begin selling the batteries as a separate product, nor used them commercially for any function other than SX-70 camera power.

design TI eventually came out with was simpler and more economical, and TI was able to turn out the components in time to meet Polaroid's production needs. All in all, however, the shift of vendors and the delay until TI could come up with the proper design cost Polaroid several months of profits and public confidence at an extremely crucial period (Figure 5.2).

New and Old Networks: Before SX-70, Polaroid's cameras were part of a growing network, which included consumers, manufacturers, as well as other stakeholders such as the photography magazines, Wall Street and so on. This entire network was situated in an evolving organizational field where picture-taking was an increasingly popular activity, and users were seeking instant gratification. Thus, Polaroid's ability to cut the time and effort of getting pictures developed was becoming more and more valued.

Consumers were now well familiar with the workings of Instant cameras, several camera manufacturers were producing Instant cameras under license, and many hi-tech companies were involved in manufacturing various parts for them. The center of the institutional field was shifting gradually from 'regular' photography to Instant photographic technology. These stakeholders had made substantial commitments to this technology and were interested in watching it blossom. With the SX-70, Polaroid broke off most of these relationships. In choosing to become a vertically integrated company, Polaroid alienated all its 'friends.' The radically new design of the SX-70 was driven more by the personal ambitions of Land, rather than by considerations of building a network around the technology. The design did not incorporate existing technological institutions - batteries or shutters, for example- and was composed of several radically different technologies, whose functional reliability had not even been proven yet, and which ws expected to get institutionalized simply because of the Polaroid brand, and the 'superior' technology.

Instead of building a chain of associations and enrolling agents proactively, Polaroid followed a reactive strategy. In 1973 the first full year of sales for the SX-70 system, the company grappled with several technical problems. The camera factory, still in its infancy, was turning out a disturbing number of defective cameras even though it was operating at only a fraction of its capacity. Polaroid failed to meet its 1973 sales goals by more than half. In the first full year of production, the company had hoped to sell 1 million SX-70 units. Startup and production problems, along with the looming recession, kept the actual figure down to 415,000.

Alienation through a Complete Control Policy

Polaroid's strategy hinged on retaining complete control over their technology. As I discussed in the previous section, their move towards vertical integration ensured that they alone were responsible for designing and manufacturing many critical parts of their camera that had previously been outsourced. Whereas previous Polaroid cameras had provided a central node for several players who aligned their efforts and interests behind Land's technology, they were now free to join other networks such as the ones forming around Kodak's Instant imaging technology or around the 35mm standard.

By way of contrast, Kodak, upon entering the Instant camera market, followed an opposite policy of sharing information about its Instant photography business rather freely with stakeholders in the industry, and promoting its particular format even at a financial loss. All one million or so Instant cameras that Kodak sold in the first year of production were sold at a loss. In fact, Kodak had been selling the EK-4 and EK-6 to retailers at significantly less than it cost the company to produce them, all the while steadily increasing its market share.

Indeed, the better image quality that Kodak had achieved in roll-film cameras was a result of innovations that occurred in several different organizations. It is another matter that, taking advantage of lax regulatory institutions, Kodak was able to retain its hold on roll-film technology (initially on cameras, and later on film) primarily through acquisitions of firms and patents. Polaroid, by restricting the technology to itself, cut off the possibility for several developments in Instant imaging technology that could have closed the quality gap. More than technological developments, Polaroid restricted the enactment of various institutions within the institutional field that could support and thus entrench its technology.

Polaroid's policy of keeping strict control over its technology was widely regarded as natural and logical by industry analysts. On the other hand, Kodak's policy of releasing information about their Instant cameras to everyone, was interpreted as an attempt to ward off possible action by the Justice Department, which for years had been considering antitrust action against Kodak. Some industry observers felt that Kodak would actually have liked to be outflanked in the Instant-picture field to demonstrate that the company was not an insurmountable heavy weight in the photographic industry. Such an interpretation was flimsy to begin with and was soon discarded when Kodak became engaged in a legal battle with Polaroid.

Kodak's Eviction: Kodak's entry into the Instant imaging field was considered a major threat by Polaroid, rather than an opportunity to further entrench Instant photography. Eastman Kodak introduced its own Instant camera in 1976. Kodak had been producing the negative component of Polaroid's black and white film since 1944, and its color negative since 1957. Shortly after viewing the SX-70 film prototype in 1968, however, Kodak terminated its partnership with Polaroid (because they did not wish to remain committed to producing a film which was soon to become obsolete), and began its own Instant-photography research. Soon Kodak entered the Instant camera market itself with the EK-4 and EK-6 Instant cameras and PR-10 Instant film.

Within one week of Kodak's introduction, Polaroid filed a lawsuit, charging 12 patent infringement in camera film and design. Eastman Kodak countered that the Polaroid suit, which had come into court after five years of legal scuffling, had been ill-conceived, hastily initiated and recklessly pursued in order to preserve Polaroid's old monopoly in the Instant-photography business. It alleged that Polaroid had a penchant for patenting every slight improvement rather than only true inventions. It further alleged this penchant had led to a vast inventory of look-alike patents, ponderous in size, bewildering in complexity, but differing only in trivial and predictable respects from each other. These patents, said Eastman Kodak, "withdraw from, rather than add to, the public's store of useful knowledge, and hence represent unwarranted monopolies which have not served the underlying purpose of promoting the arts." Why then, asked Polaroid, did Eastman Kodak at first hail the SX-70 as "a masterpiece of engineering" and why did Eastman Kodak acquire, by October, 1974, more than 30,000 SX-70 film cartridges and 70 SX-70 cameras for analysis and testing? (Wensberg, 1987).

In any event, Kodak was making giant strides with its Instant cameras. Retailers reported that as a result of Kodak's strategies, Polaroid's domination was dwindling.

Already in Canada, retailers claimed that Kodak's EK6 model was outselling Polaroid's equivalent model, the Pronto. While most dealers rated the two cameras a toss-up in quality, many favored Kodak in their merchandising because of higher profit margins. On the new Kodak cameras, said dealer Paul Schutt, president of Helix Ltd. in Chicago, "We'll make $1.50 or $2." By comparison, he said he bought the Polaroid Pronto for $46 and sold for $46.50. "There's no real profit in the Polaroid line, but a dealer has to carry it," Schutt noted (Business Week, 1976).

Despite its aggressive promotion of Instant photography, Kodak was careful not to cannibalize its own regular photography business. Indeed, in August 1977, Advertising Age noted that Kodak's traditionally saturating advertising was not keeping pace with market growth, and that it was possible that the company was purposely holding back from an even greater share of the market to avoid further antitrust threats (*Advertising Age*, 1977). This holding back strategy could also be interpreted as an effort to control the penetration of Instant into regular photography.[32]

Kodak won two victories before the trial opened. In July, Judge Rya Zobel ruled that the patent covering the trapping of fluids used in the film development process of the SX-70 was invalid, because the trapping element had been well known beforehand. Polaroid also voluntarily withdrew its infringement claim on the crank handle used in one of Kodak's cameras. The stakes appeared high to Polaroid. The company's earnings had shrunk as Kodak had won 35% of the market in a soft economy and as Japanese 35mm imports had grown. Victory in the court could mean royalties worth tens of millions to Polaroid. Defeat could open the door to even more competition.

In 1990, after a bitter and protracted battle, the lawsuit ended in favor of Polaroid, which was awarded $909.4 million in damages. This was naturally a big blow for Kodak, which was ordered to stop the manufacturing and sale of all Instant products, thereby losing a $500 million business along with all its existing commitments to the technology. All consumers who owned Kodak Instant cameras could either switch to Polaroid or to the other emerging alternative 35mm cameras. Since the formats of Kodak and Polaroid cameras were different, film was a major problem for Kodak camera owners. Polaroid refused to manufacture film for the millions of Kodak cameras that became obsolete as a result of the ruling. Instead, Polaroid offered customers film coupons worth $10 as an incentive to buy its Instant cameras. Kodak, on the other hand, offered Instant camera owners the opportunity to trade their Instant cameras for Kodak disk cameras (Kodak's new photographic technology) and two film cartridges, or a coupon book for discounts on Kodak products. Dealers were also given full credit when the products were returned to Kodak.

Polaroid celebrated Kodak's eviction enthusiastically with little regard for the possibility that Kodak's eviction meant that instead of dedicating all the company's resources to Instant imaging, they could now be at the disposal of some other competing network. Kodak's presence in the Instant imaging field was a great source of conviction for Instant photography's several existing stakeholders as well as a major source of affirmation for those aspiring the join the Instant imaging network. Kodak's exit meant a severe loss of credibility for the Instant photography format.

Relations with Dealers: Dealers were an important ally in the diffusion of Polaroid technology among the masses. However, because of Polaroid's monopolistic position, they were treated like a necessary evil rather than a valuable part of the network. It was only when Kodak entered the fray that Polaroid attempted to hastily spruce up its dealer relations. Before then, those relations were weak -- which gave Kodak one of its biggest marketing advantages. But as the heat from competition began to reach Polaroid, dealers saw a remarkable change in Polaroid's attitude. Broadway Photos owner Mr. Stapleton noted, "Polaroid has become more attentive to its customers. It's a feeling we get from the salesmen. Before, we called them. Now, they call us. And specials on cameras and films that we used to get a couple of times a year, we're now being offered once a month." (*Business Week*, 1976)

The dealers were never taken into confidence about innovations either. Again the case of the SX-70 is illustrative. Because of Polaroid's carefully orchestrated campaign of alternately revealing and holding back, by the time of its public release the SX-70 was among the most keenly anticipated consumer products of all time. At the 1971 annual meeting, Land had tantalized the audience and press by plucking an SX-70 prototype from his pocket but replacing it there without taking any pictures. And from the

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[32]Kodak's strategy in the digital camera case reinforces this notion.

photographic and technical publications of those months, it became obvious that the editors had discerned no clear pictures of the process from the Patent Office searches. Even after the 1972 meeting, at which the camera was first publicly clicked, Polaroid would not announce any plan for national distribution[33].

As the camera war between Polaroid and Kodak heated up, Polaroid offered what it called special-edition models to selected dealers throughout the country. The cameras, which were not advertised or available in discount houses, cost the dealer a few dollars more than standard models. The buyer, however, received a coupon with the special-edition models that permitted the return of any pictures deemed unsatisfactory and promises that Polaroid would replace the film free. The coupon was good for five years, and there was no limit to how many times a buyer could get free film within that period. "If they make 40% margin on their film, they're still way ahead if they get 10% of the pictures back," says Paul Schutt, a Chicago dealer. Despite the dealers' protests, Polaroid advised dealers to avoid advertising the camera (*Business Week*, 1976).

Finally, Polaroid's technology strategy also helped alienate its dealers. For instance, the decision to design a completely new battery for the SX-70 contributed heavily to lost sales for dealers. In the initial stages of the SX-70's commercial life, the exceptionally short battery life meant that production had to closely follow sales. Stockpiling of large quantities of film right off the assembly line for future selling was impossible since by the time it reached store shelves, the batteries could be dead. Therefore, the plant could only produce as much film as could be sold in the next month or so, which meant that none of the plants was operating anywhere near max efficiency. The short shelf-life of batteries rendered several thousand film packs useless to retailers, adding to their mounting frustration. Polaroid reacted by opening service centers in major cities across the US in an effort to help consumers with their problems and other similar initiatives. However, they had already provided stakeholders in the institutional field with enough incentive to align behind alternative technologies.

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[33] This was less a case of trying to build anticipation than acknowledging that production had not been regularized to the point of normal predictability. Many of the facilities were operating at less than 40% of capacity, nor had they yet been effectively coordinated with each other.

Marine Sonar. Yet another reflection of Polaroid's bid for complete control was the marine sonar, which was developed for auto-focusing. Polaroid had patented the sonar system that emitted an inaudible chirp. The sound reflected from the subject to the focusing machinery on the principle of the sonar depth-finding instruments in universal use at sea. Automatic focusing using ultrasonic echo ranging in the family of SX-70 cameras was powered entirely by the battery. A later form of the sonar, the Polaroid transducer, was cheap: it added about $3 to the price of the SX-70 camera and only a little bulk (*Business Week*, 1980). It was virtually foolproof (but one couldn't take pictures through a closed window; the sound wave bounced off the glass and the camera focused on the window, not on the subject beyond it). Unfortunately, Polaroid chose not to license the sonar to anyone else in the camera trade.

Polaroid's bid to control its technology extended beyond jealously protecting its patents and not allowing any other stakeholder to manufacture Instant cameras on its own, to a complete dismissal of any need for designing and positioning its technology in a way that others could embody their interests in it. Consumers were only one node in the growing network that surrounded Instant photography. Several other stakeholders needed to be convinced and aligned behind the technology if it was to attain dominance. Also, the technology needed to be associated with existing practices and routines in order to facilitate its institutionalization. For instance, to begin with, the technology had to be reliable, i.e., it needed to function as it claimed. If it did not, it was not only Polaroid which took the hit, but also the several thousand retailers who were not responsible in any way, but still were forced to face dissatisfied customers, thereby questioning their decision to stock the products at all. Moreover, several manufacturers who were licensed to produce various parts or entire cameras by Polaroid were forced to upgrade their technology each time Polaroid came up with a new system. Polaroid had little concern for their ability to do it, and even less for keeping this network together.

As brilliant as Polaroid's innovations were, they could not dominate the market alone. Land, however, thought differently. "Virtue and a good product are invincible," he maintained. He had ultimate faith in the individual innovator. He believed that only the individual, and not the larger group, could see a part of the world in a totally new and different way. In this backdrop, Polaroid's inability to fathom the importance of networks to the construction of a technology is not surprising. The company continued to believe that if a technology were superior, it would eventually be successful.

Disdain for Photofinishers and Wall Street

Photofinishers. A significant development in the 1960s and 70s was the emergence of a new, powerful stakeholder group in the field: photofinishers, who developed and printed photos for all formats except Instant. Their sales broke $1 billion in 1971 and $1.5 billion in 1975 for processing alone (Figure 5.4). Along with hundreds of other companies, Kodak participated in the boom by processing film directly. More significantly, the company supplied other photo-finishers with photographic paper, sensitized materials, and photofinishing equipment. Industry analysts conceded Kodak's preeminent positions in both sensitized materials and finishing equipment sales. Although the company did not release market share data, experts believed Kodak was responsible for more than 50% of the multi-billion dollar market in sensitized materials and almost 100% of the finishing equipment market (Merry, 1984).

Figure 5.4 About Here

Polaroid, on the other hand, was not part of this boom. Moreover, it did nothing to enroll this new, increasingly powerful group of stakeholders, perhaps because the fragmented, small-guy appearance of photofinishers made them look vulnerable. Most analysts believed the photofinishers were threatened by Instant photography. The SX-70 and Polaroid's continuing technology policy of going it alone while focusing on absolute ideals, however, proved such fears to be unfounded. Indeed, in 1977, photofinishing volume reached $ 1.8 million while for 1978 it approached $2 billion. Of this some 96% represented color processing and printing for formats other than Instant. (*British Journal of Photography*, 1978)

Wall Street and the Media. Increasing reliance of companies on external financing introduced Wall Street as a major stakeholder in the field. Polaroid, however, with its deeply institutionalized culture of innovation and internal financing saw little need to enroll this influential player. Polaroid's board meetings were completely dominated by the revered figure of Edwin Land. Board members and the press alike believed his touch was golden. The man was a genius, with a number of patents to his name that was second only to Edison's. At each meeting Land displayed and sometimes demonstrated the new products that Polaroid was working on. Almost always, everybody was fascinated by the futuristic technology. Nobody dared ask him if the new product would make money. With the success Polaroid had enjoyed, that was assumed automatically. Wensberg narrates the story of an annual shareholders' meeting where Land demonstrated the brilliant but ultimately financially disastrous Polavision technology. While everyone sat enraptured by the fascinating technology, one young financial analyst from Wall Street asked the killer question: "but what about the bottom line?" he asked. "The bottom-line," spoke an obviously irritated Land, "is in the heavens." The whole hall broke out into thunderous applause. (Wensberg, 1987)

Land believed that Polaroid's increasing problems were a product of the stakeholders in the field, especially the media. It never occurred to him that just like problems, success could be (choose one: manufactured by the / determined by the) stakeholders too. Throughout the low points of 1974 and 1975, Land continued to proclaim his company's health. When a Forbes magazine interviewer asked him about Polaroid's recent problems in 1975, Land responded:

> 'What problems? Those problems are largely problems in the press.' He also insisted on turning the SX-70 start-up difficulties into experimental plusses: 'I think the battery saved us, because without the troubles with it, we would have been spoiled and we would have been growing too fast. It was a happy accident, a cloud with a very silver lining. There are no problems at Polaroid, only wonderful opportunities.' (Chakravarty, 1975: 48)

Breakaways. A purely licensing arrangement limited the commitment of stakeholders to the technology. Around 1975, Corning Glass Works decided to halt production of SX-70 lenses because of insufficient volume from Polaroid to keep the operation profitable. A Corning spokesman told the Wall Street Journal, "This is just the story of a product that didn't do to well in the marketplace. From what I read, it seems that they [SX-70s] were a great disappointment for Polaroid – and as a consequence, a great disappointment to Corning and other suppliers." The trend of 1975 duplicated that of the previous year. The first-quarter earnings were down 17 percent from the already meager 1974 first quarter, threatening to produce the first deficit year for the corporation since the introduction of the original Instant camera.

Competition from 35mm Format

By the mid-1970s, the competitive environment in consumer photography had started changing. Polaroid had had essentially no competitors for most of its existence; now competition for Instant photography came from a number of sources. After having been around for more than 30 years, 35mm cameras were fast becoming popular (Figure 5.5). This was despite the fact that neither of the two giants in the American photography business, Kodak[34] and Polaroid lent their support to this format. Associated primarily with Japanese companies, these cameras were rejected by Polaroid, where Edwin Land maintained in a letter to shareholders in 1981 that the Japanese were responsible for introducing "cameras of unfortunate bulk, films of unfortunate expensiveness, and propaganda directed towards treating this most elegant of arts as a toy." (*Economist*, 1982).

Figure 5.5 About Here

The rapid ascent of 35mm in the 1970s and 80s, a format which had been around for several decades, could be attributed to the significant commitment of Japanese competitors. The competition among the five Japanese brands that were behind 35mm led to furious price-cutting and reduced margins, as each producer attempted to gain or strengthen its foothold in a major new segment of the camera market. However, while the Japanese firms provided the initial commitment to the 35mm format, any one agent did not control the design. Indeed, it embodied the interests of several members of the

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[34] Kodak was preparing to launch the 'disk camera,' based on a proprietary technology which they could control entirely.

institutional field including manufacturers of cameras, films, photofinishers and retailers. Thus major advancements were made not only in cameras, but also in film quality and photofinishing. The open design allowed the rapid development of 35mm cameras. As the design evolved it came to incorporate innovations by several hi-tech companies working on different aspects of the camera (optics, electronics etc.). At the same time, the design incorporated existing technological institutions (ordinary batteries, flash, autofocus etc.) thereby transferring all routines associated with these standards to the nascent design.

The rapid development of the 35mm format led to the establishment of new standards in photography. The compact 35mm SLR that incorporated several electronic systems was fast becoming the new standard. These cameras excelled at all the prevailing evaluation criteria (quality, compactness) and their prices were coming down too because of the commitment that Japanese firms showed; they took losses for several years before they could break even in the American market. The limit of 'compactness' was now established around the standard set by the Olympus OM-1; in practice 'compact' was applied to a camera noticeably shorter in length than those of early 1970s. The most talked about camera in the late 1970s was the Canon A-1 in which almost every conceivable use of electronics had been incorporated. The fully automatic meter system could be switched from shutter to aperture priority and all functions read out in LED displays in the viewfinder, including intermediate shutter speeds and f/stops.

During the early 1970s, the U.S. market for high-priced, professional Japanese cameras grew at an impressive rate, but in the mid 1980s, it showed signs of reaching saturation. To make matters worse, the growing value of the yen against the dollar and rapidly rising labor costs in Japan were pricing the sophisticated models beyond the reach of many potential consumers. At the same time, however, the development of low-cost integrated circuits, cheap but durable plastics and automated manufacturing techniques were making possible the mass production of high quality but low-cost 35-mm cameras.

35mm cameras were backed by expensive mass-media advertising campaigns. Canon, for example, spent $15 million on its U.S. advertising in 1976 - roughly five times the 1975 level. Such heavy promotion, and the astonishing success of the AE-1, boosted Canon's U.S. photo sales to $206 million in 1976, 500% above 1974, the year before the new camera's debut.[35] Similarly, to create a market for its new EM, Nikon doubled its U.S. advertising expenditures in 1977. And Pentax spent heavily to promote its fast-selling SLRs, which helped to increase its share of the 35-mm market from 8% in 1976 to 17% the next year.

With their new products, the Japanese were not only attempting to lure novice American photographers away from Kodaks and Polaroids but also to get them hooked on a photo habit that could lead them to trade up to more professional and costly lenses and cameras. In its advertising to promote its new automatic SLR, for example, Nikon reminded consumers that by purchasing its EM model they automatically joined the Nikon system. The onslaught of the Japanese and their advertising strategy re-positioned the camera and re-defined photography. It was not a device for preserving memories anymore, but had now assumed the role of a life-style product. One could identify with various brands of cameras just as one could relate to brands of cigarettes or beer!

Moreover, the 35mm network strengthened whenever a new firm decided to sell, design or manufacture 35mm film or cameras. And the format was completely open, so newcomers poured in. Despite the rapid evolution of the 35mm format, Polaroid continued to focus on its proprietary Instant technology. However, it was now playing on its competitors' turf. Indeed, its advertising focus had shifted from highlighting the differentiating aspects of Polaroid technology to an emphasis on its performance on popular criteria. Thus, it claimed its cameras to be "*the Camera that thinks of itself as a 35mm*" and proceeded to introduce 35mm film. It also introduced a new model Spectra in 1986, which lifted sagging sales to some extent before becoming buried under the onslaught of 35mm models in the market. With a reported resolution of 3.6 million pixels the camera was positioned between the traditional point and shoot cameras (110 and Disc) and 35mm on the basis of price and resolution, rather than the different 'lifestyle' it implied. It was telling that the first casualty of the 35mm was the 110mm format, not Instant photography. In fact, Instant photography was widely held responsible for the demise of 110 (probably the most popular format ever in the history of photography)

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[35] During that period, Canon leapfrogged Minolta to capture first place in the domestic 35-mm market, with a 28% share.

because both 35mm and 110mm were sold primarily at non-specialty outlets while almost 40% of initial Spectra sales were derived from specialty camera dealers.

Polaroid's ultimate demise is often attributed to the improvement in the quality of 35mm film, the advanced features available in 35mm cameras at decreasing prices, the simplicity of their use, and to the development of minilabs. Similarly, Polaroid's initial success is attributed to the novel idea that it represented. In this chapter we have challenged these rather deeply entrenched views. I have argued that minilabs were a phenomenon that gained strength after the demise of Instant camera had already begun (Figure 5.6). Rather than minilabs causing Polaroid sales to decline, it was Polaroid's strategy of alienation that allowed minilabs to grow. I have argued that Polaroid's success, when the cameras were expensive, the procedure messy and photos of poor resolution, was first due to several institutional changes that were coming about at the time, and which converged in the expectation of instant gratification from every activity, and second because of the peculiar interaction of Polaroid's operation and the ritualized occasions where these cameras were used.

Figure 5.6 About Here

Similarly, I argued that Polaroid's demise was ultimately brought about by its refusal to acknowledge that its technology, however brilliant, was not absolutely superior. Superiority is an acquired trait and requires that stakeholders support the claim made by the proponent and rally behind the design. Ensuring their support in turn requires opening up the design to incorporate their interests in it. Furthermore, the institutionalization of the nascent technology requires building associations with existing technological and other institutions. Polaroid's strategy appeared oblivious to these considerations. It focused on attaining the perfection of photography. Its design was based on radically new technologies, which broke away from existing institutions rather than link the nascent technology with them. While the 35mm format, based on an open design, was fast attracting emerging and existing stakeholders, Polaroid was bent upon going it alone. In fact, Polaroid distanced itself from its existing network too, by obsoleting its own technology. Finally, Polaroid failed to see how their technology actually fit into consumers' lives and continued to emphasize elements that were irrelevant to consumers. Instead of *emphasizing* the cultural aspect of the technology and its ability to add life to social occasions, it overlooked it in favor of emphasizing the technological aspects of the new products.

CONCLUSION

The case of Polaroid provides several insights relevant to the research questions driving this study. On the question of whether technological superiority is inherent or acquired, for instance, Polaroid's case offers evidence that casts doubt on the technologically determinist argument that the best technology inevitably wins. The case reinforces the possibility that rather than being inherent, superiority is an acquired trait. Indeed, since Polaroid and traditional photography had radically different features or capabilities, they could not be easily compared. Not only was superiority of the product a multi-dimensional construct composed of a changing mix of features such as image quality, Instant imaging ability, price, ease of use. But even within this set, each feature was complex. Image quality, for instance, could be defined on the basis of close-ups, action shots, low-light situations or enlargement ability, and so on. In each of these situations, the multiple possible combinations of film and camera produced a different quality image, for instance, digital cameras produce images that are comparable to 35mm pictures until they are blown up, upon which their quality deteriorates seriously. However, since the mass market exhibits a regular pattern in the choice of subject and situations, it becomes possible to distinguish on the basis of quality. Naturally, when these patterns change, so does the criterion on which quality is measured. For example, when photography was used mainly for portraits, quality was judged on grain size (the finer the better) and sharpness of image. However, these criteria have expanded to include how 'fast' the film is,[36] and how accurately the camera can adjust to low/high light situations etc. Similarly, the tradeoffs between ease of use, Instant imaging capability or image quality are extremely difficult to specify since using customer

[36] The faster the film, the better it can capture action situations. However, normally, as a film gets faster, it loses sharpness and the grain becomes thicker.

response as a proxy entails the danger of assuming that the successful technology was necessarily the better one. Instant imaging produced pictures of a quality comparable with traditional 110mm and 126mm cameras, and the user did not have to wait. Prices were also comparable among Instant and traditional cameras, making the 'Instant' element the primary basis for comparisons. However, it remained to be seen whether traditional was superior to Instant or vice versa. Indeed, it required building a normative and cognitive institutional context in which Instant photography would appear as the obviously superior alternative, as had happened with roll film technology at the turn of the century.

Another question that was posed in the theory section concerned the impetus for change. Institutional theorists have proposed that the impetus for radical change should come from outside the institutional field, a proposition that finds support in the case of Instant imaging. Polaroid was indeed an outsider with little legitimacy in the photographic field, except perhaps as a supplier to Kodak. Kodak's domination of the film and camera market was virtually monopolistic when Polaroid arrived. A radically different technology, which was more expensive than traditional cameras, more complex to operate and produced (at least initially) poor quality photos, did not have much of a chance in the experienced opinion of Kodak. Polaroid, however, persisted and it was precisely its contempt for market studies that allowed it to introduce a socially unsanctioned technology into an established institutional field. Land's comments after the introduction of SX-70 sum up Polaroid's attitude: "The SX seems to be defying conventional marketing presuppositions, as we planned that it should." (Olshaker, 1978)

I also set out to explore the room for managerial agency in technological evolution. In the case of the roll-film camera we observed a systematic effort by Kodak to make its design - that had flopped earlier - dominant. Kodak leveraged institutional changes occurring in the society to change the popular understanding and practice of photography, while eliminating all technological and competitive challenges. In Polaroid's case too, agency was central, but a very different strategy, which appeared to derive from Polaroid's own understanding of its technology, was observed. As discussed earlier, Polaroid always considered photography to be an individual activity. However, as discussed in Appendix 2, since Kodak's introduction of the Brownie, photography had become a socially motivated activity. Moreover, pictures were not artifacts anymore that contained memories, but served several other social functions. Accordingly, Kodak had successfully attempted to get photography to lose its 'serious' activity perception and truly become an activity for the masses. Polaroid, on the other hand, aimed to take the masses to photography. Thus, when a *Forbes* interviewer commented to Land that "some people feel that the original SX-70 was too good a camera for the amateur," Land responded:

> Ironically, it is some of the liberal press who thought that worthwhile photography was too good for the common person. I would like to see most amateurs get as good as most professionals because it would enlarge their horizons.... I believe that this camera [SX-70] will be a necessity to everyone, once they learn how to use it. (Chakravarty, 1975: 48)

Polaroid's belief that photography was an individual act led them to understand that sophisticated, 'superior' technology would generate its own demand. There was no need, in Polaroid's view, for putting together a large network to support this technology. This was apparent from Polaroid's product design (for the SX-70), licensing and patenting policies. For instance, Polaroid's decision to design the SX-70 (a half-billion dollar investment) from scratch led to the break up of existing relationships with several stakeholders. Most of these stakeholders joined the 35mm network which was based on open architecture. Thus, while Polaroid ensured that nobody else could embody their interests in Instant technology, 35mm fast arose as an agglomeration of several different interests. Similarly, Polaroid's insistence on maintaining a strict control over the technology effectively prevented Instant technology from becoming a platform on which new technological as well as social institutions could grow.

While the disruption caused by Polaroid's introduction of Instant photography was quite different from that created by Kodak, they both had to deal with issues that threatened to deny them legitimacy. When roll-film was introduced, mass photography was an unknown concept: Kodak needed to develop an entire understanding of photography around its technology. On the other hand, when Instant photography was introduced, photography at social occasions was an established institution among the masses. However, critics were quick to point out the poor quality of the prints, the messy chemical brushing that they needed, the unavailability of copies or enlargements, and the high cost per print.

As in Kodak's case, Polaroid's initial technology changed around these issues. The messy process of coating prints with chemicals that was part of the initial designs was eliminated, quality improved to the satisfaction of people like Walker Evans and Ansel Adams, and the cost was brought down. However, all these changes were primarily contained within the design and did not produce new stakeholders. As a matter of fact, Polaroid did its best to make the technology self-contained and *discouraged* the expansion of the institutional field. This was especially true after SX-70. Before the SX-70, several firms (e.g., negative manufacturers (Kodak), battery manufacturers etc.) were stakeholders in Polaroid's designs. Moreover, the relatively simple design allowed several firms to license the technology and produce cameras for Polaroid. The SX-70 brought all these relationships to an end (see Table 5.2). Thus, Polaroid's greatest innovation shrank the field rather than expanding it.

Table 5. 2: What the SX-70, a Half-Billion Dollar Investment, Entailed.

POLAROID'S ADDITIONAL RESPONSIBILITIES AFTER SX-70
1. Camera Assembly Plant (Previously cameras were manufactured by U.S. Time and Bell Howell, with Polaroid handling sheet and pod production along with some final assembly.
2. Expansion of existing chemical production and film packaging facilities
3. Production of Negatives (Previously produced by Kodak)
4. Production of Polapulse Battery (radically new design: Battery in film pack)
When the SX-70 was introduced, Polaroid's $30 Colorpack Camera was already successfully placed in the market. The SX-70, with a $180 price tag, appeared to compete with top-end traditional SLR cameras. Polaroid only broke even in 1974 (on a variable manufacturing cost basis) and became profitable in 1976. Meanwhile sales were nowhere near expected. In order to boost sales, Polaroid introduces three cheaper versions of the SX-70, culminating in the Model IV Pronto!, which retailed for $66. An even cheaper model the Supershooter Colorpack retailed at the time for $24.95.

Primary Sources: Wolfman Reports; Olshaker, 1978; Wensberg, 1987.

On the other hand, the network supporting this new format was growing, primarily due to Polaroid's monumental efforts to keep others out. Specifically, the new 35mm network strengthened because of the participation of photofinishers, Kodak, the entire Japanese photographic industry and dealers, who got much better deals on 35mm cameras than on Instant ones. Photofinishers had always been threatened by Instant photography, Kodak had been forced out of the Instant camera market and the Japanese centered around an open standard where they could develop the technology further rather than licensing from Polaroid.

The 35mm format was neither superior, nor inferior to Polaroid until at least the mid-1970s. If it became widely adopted afterwards it was because the openness of the standard attracted several firms to join the emerging network. Film and camera manufacturers, chemical suppliers, parts-suppliers, photofinishing equipment manufacturers and photofinishers, all innovated in their respective capacities. The film quality became better due to innovations by Kodak, Fuji, GAF and Ilford. Fuji, for instance was responsible for introducing supersaturated colors, which were unnaturally bright, (almost fluorescent)[37] as well as a 400 speed film (and later a 1600 ISO film). Similarly, Canon introduced an infrared rangefinding system and Minolta introduced the now standard autofocus lens. The Japanese companies took full advantage of the electronic revolution to automate various features of roll-film cameras, bridging the gap between point and shoot cameras such as the 110mm and SLRs. The proliferation of photofinishing outlets reduced the time spent on developing photos, getting a tremendous boost from Fuji's introduction of the minilab, an automatic machine in which film rolls were inserted from one end and prints received from the other.

The openness of 35mm allowed firms to modify the design to suit their manufacturing and introduce innovations that gradually led to the evolution of a 35mm camera by the 1980s, which was user friendly, automatic, reliable, efficient, pocket-sized and included built-in flash, rangefinder, autofocus and automatic film rewind features.

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[37] When Fuji's market share continued to increase at the expense of Kodak's, the latter commissioned market research which showed, much to their astonishment, that consumers preferred colors that were *not* accurate. Fuji's colors were unnaturally bright and oversaturated (the Greens are greener, reds redder) compared to Kodak's which were more *real*. Fuji never had a problem convincing customers of its

Moreover, these cameras came in various shapes and sizes but all took the standard 35mm film. The proliferation of these cameras bolstered the institutional understanding of photography that centered on traditional photography. Even as Polaroid ran into financial problems, it refused to let go of its proprietary technology, eventually making way for the now superior 35mm format and idea of photography.

The peculiar effect of Polaroid's innovation on the existing field adds substantial variance to existing studies of technological discontinuities, and represents an issue that needs to be explored more. Tushman and Anderson's (1986) competence-destroying vs. competence-enhancing discontinuities, or Henderson and Clark's (1990) architectural innovation, do not quite explain this technological change. Rather than competence-destroying or competence-enhancing, the design of the SX-70 was a network-destroying innovation. The two cases, Kodak and Polaroid, thus offer a study in contrast. Whereas in Kodak's case the technology had a fragmenting effect, in Polaroid's case, it had a consolidating one (consolidating the various activities performed by stakeholders into the central design). Does a network-destroying innovation exhibit different dynamics than a network-enhancing one? Do the two different types of innovations, or discontinuities always lead to different technological outcomes? What does it imply in terms of dominance? All these questions will be dealt with in Chapter 8.

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high quality. When Kodak realized that consumers wanted Fuji's supersaturated colors, it introduced its VR-G line of films.

FIGURES TO CHAPTER 5

(Data for all figures has been taken from Wolfman Reports and PMA Industry Trends Reports).

Figure 5.1a: Instant's Sales as Proportion of Total

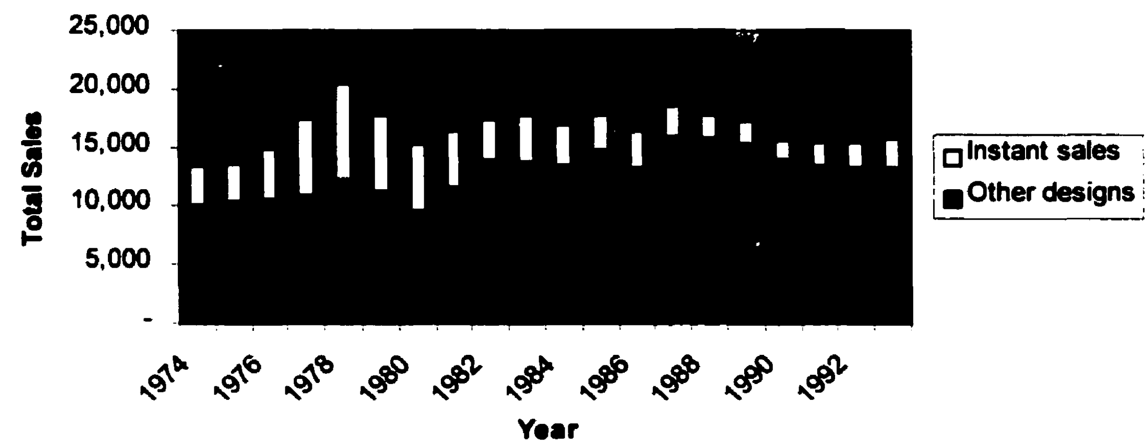


Figure 5.1b: The Demise of Instant Cameras

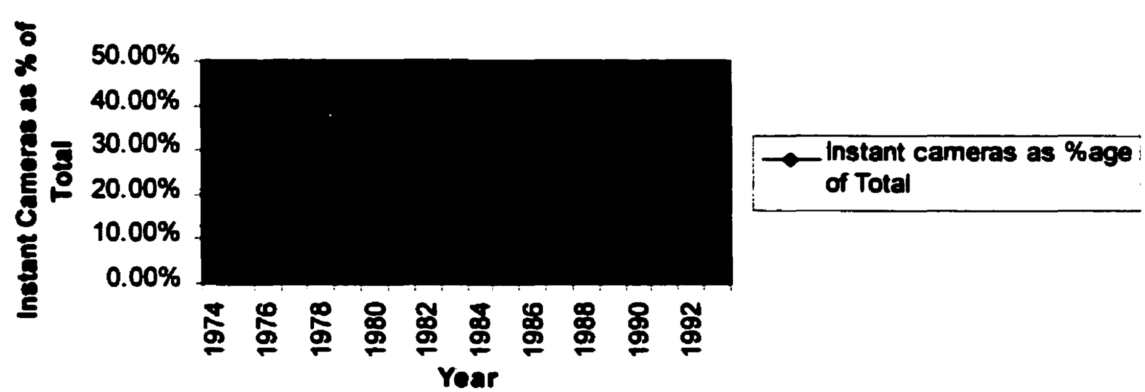


Figure 5.2: Polaroid Profits

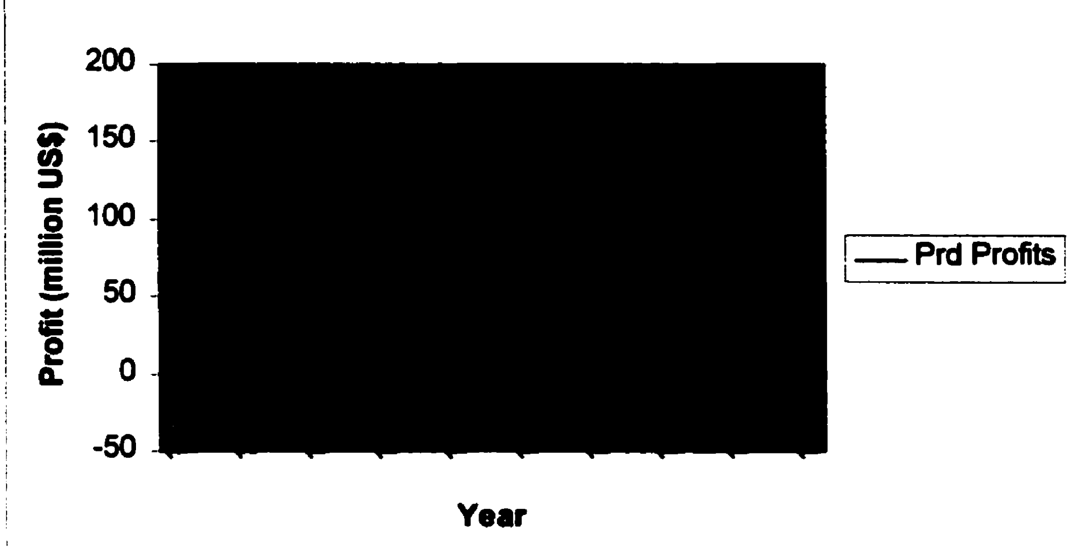


Figure 5.3: Instant Camera Sales

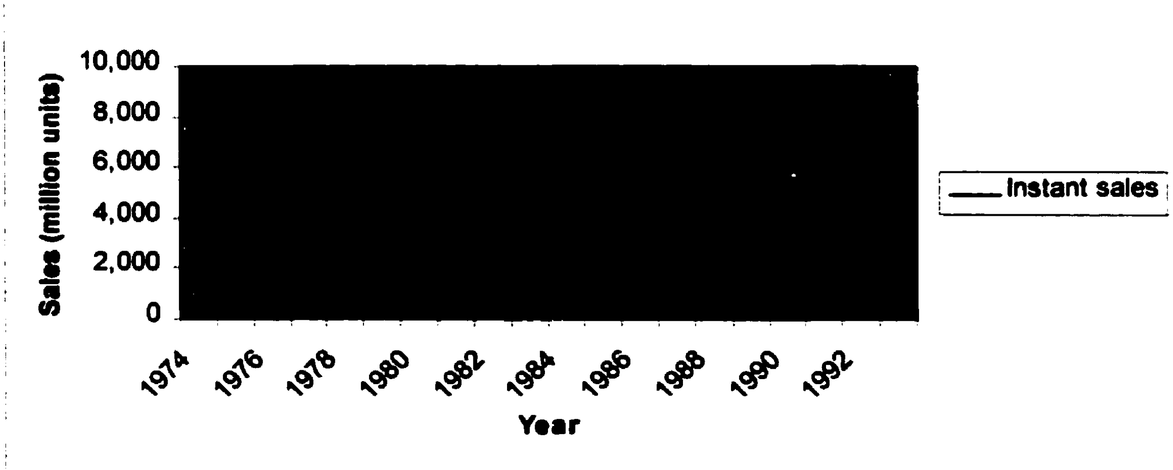


Figure 5.4: Rise of 35mm and Demise of Instant

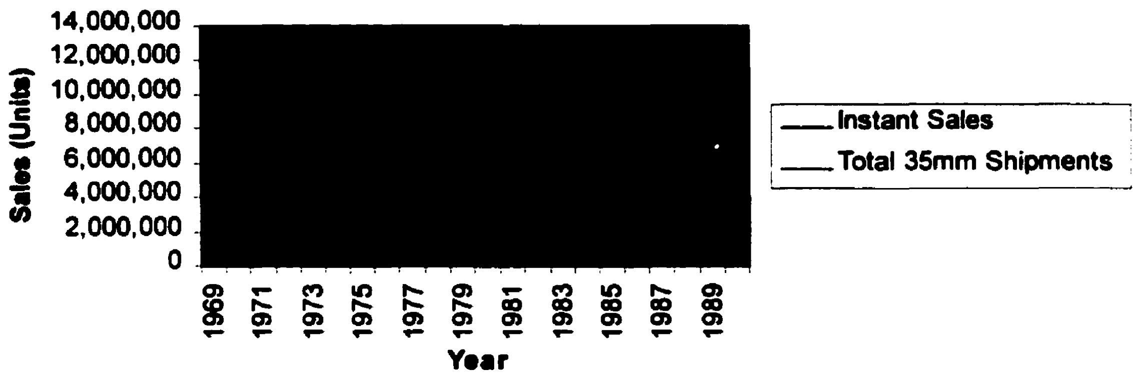


Figure 5.5: An Emerging Power Base: Photofinishers

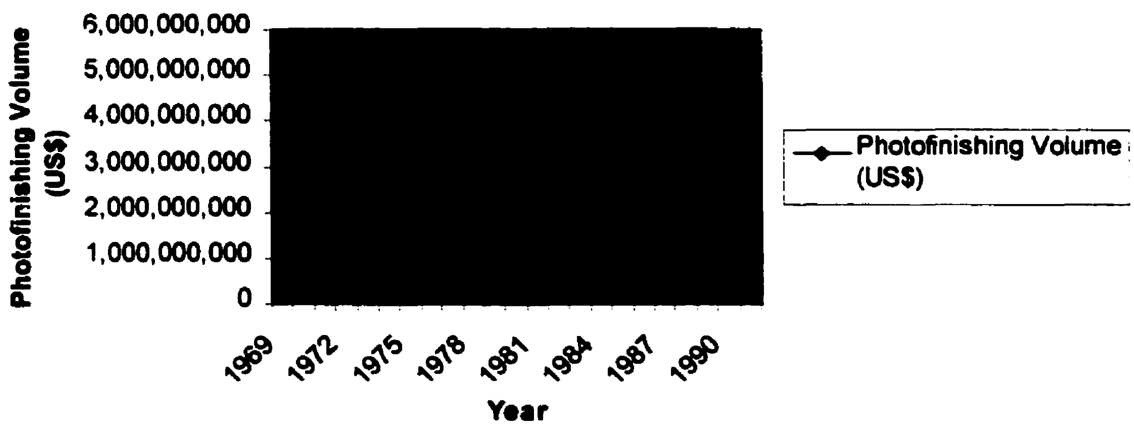
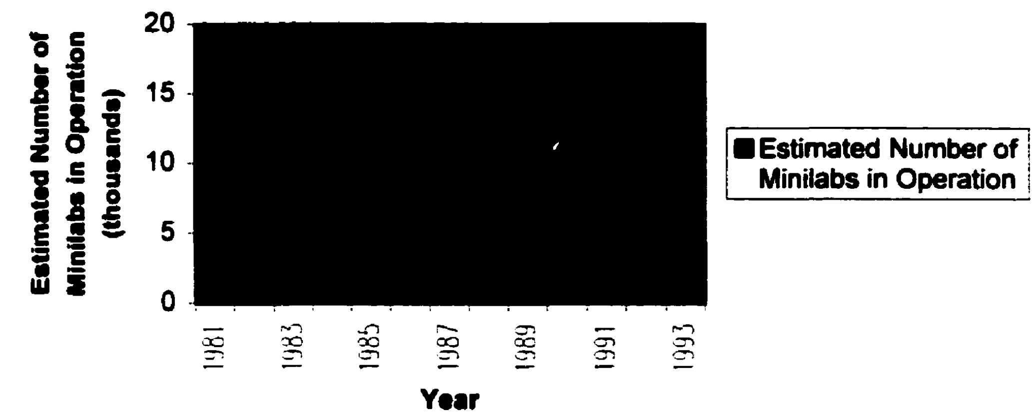


Figure 5.6: The Increasing Penetration of Minilabs



CHAPTER 6: FAILURE OF THE KODAK DISC CAMERA

External actors are not always responsible for introducing disruptive technologies. Incumbents may also have reason to do so. Indeed, increasing threats to Kodak's almost monopolistic control over its industry motivated the introduction of disc technology. The disc camera system was introduced in order to perpetuate Kodak's dominance and control. By all accounts, it was expected to be the future of photography. However, despite the enormous clout of Kodak's state-of-the-art technology and exemplary design in response to consumers' perceived needs, it not only failed to establish dominance, but also fizzled out within a few years of introduction. While the story of the disc camera is now relegated to the annals of photographic history as a failed experiment, several insights relevant to the research at hand can be drawn from it. Since the disc camera is a case of failed technology, it nicely supplements the already discussed cases of the roll-film (success and dominance) and Instant (short-lived success; no dominance) technologies.

In describing this case, I begin with an introduction to disc technology. I then discuss how its initial success was attributed to its high quality and ease of use. When sales started falling sharply soon afterwards, the same quality was labeled as poor and held responsible for the disc's demise. Finally, I discuss the actual causes of the disc's failure. The case is illustrative of how technological quality comes to be constructed, at least partially, in the social context rather than entirely in laboratories. Moreover, the case also provides insights into the development of an institutional field. Contrary to Hoffman's (1999) thesis, it seems that a disruptive event does not always lead to a new institutional field. A complex interplay of several forces - economic interests being the foremost among them - was responsible for the classification of disc photographs as poor quality, and the absence of support for this new design.

INTRODUCTION OF THE DISC

In the late seventies, three different technological standards were operative in the photographic industry: 110mm, 35mm and Instant photography. All three embodied the interests of different players in an overlapping fashion. For instance, 110mm 'Pocket Instamatic' cameras were the mainstay of industry leader, Kodak. These cameras had been a spectacular success, with Kodak selling more than 60 million Instamatic cameras by 1975 in just a little more than a decade. During this same period all of Kodak's competitors combined had sold, by most estimates, no more than 10 million Instamatic type cameras. 110mm cameras constituted around 48% of all camera sales in 1976 and thus dominated the market. Instant cameras, on the other hand, a market which Kodak had just joined in 1976 was completely monopolized by Polaroid's various models and formed around 30% of the total amateur camera market. Finally 35mm cameras, mainly sold by Japanese companies, formed around 8% of the market (Figure 6.1).

Figure 6.1 About Here

Traditionally, the photographic industry had been dominated by a systems approach. For instance, until Polaroid began to challenge its hegemony in the 1950s, Kodak's roll-film camera and film system had almost completely monopolized the industry. While on one hand, Polaroid's Instant cameras were cutting into Kodak's sales; on the other the 35mm format, which had until recently been relegated to the margins, had suddenly picked up momentum in the 1960s, as it had uniformly become the choice of all Japanese companies such as Pentax, Minolta, Canon, Olympus and Nikon. In 1982, 35mm cameras overtook total sales of 110/126mm cameras produced by Kodak (Figure 6.2). While Kodak still controlled around 85% of the total film market, the open standard of the 35mm format had broken the systemic nature of photography. Traditionally, Kodak had relied upon its patents and its control over the retailing and photofinishing market to exclude any competitors from its system. 35mm posed a threat since anyone could manufacture film and cameras. Moreover, there was always the threat of a new format being introduced by a competitor with the likely scenario of Kodak having to play catch-up in the film department (where the majority of the profits are made). The only defense left for Kodak was its clout.

Figure 6.2 About Here

The disc technology system was Kodak's attempt to bring back the system approach and thereby restore its control over the industry (Figure 6.1). It also served as insurance in the face of Kodak's increasingly likely loss of the case against Polaroid. The disc would give Kodak an alternative technology, which could meet the Polaroid challenge head on, targeting the same group of consumers. From Kodak's perspective, the new disc technology that was being developed in Rochester for several years now, was the ideal response to all these strategic considerations. The camera, or rather the photography system, was a result of several years of research and market studies by Kodak. Market studies, almost unanimously indicated that consumers preferred smaller cameras which offered easy loading of film, sophisticated automation (auto-focus, electronic light meters, shutters, and so on) and enabled lay persons to shoot good quality photos in a simple fashion. The disc technology met all these criteria. Indeed, Kodak had put its all into the disc system, to the extent of even discontinuing all 35mm camera production and announcing it would never again make 35mm cameras (*Popular Photography* Nov. 1993).

The new format was radically different from anything the market had experienced before, and in accordance with Kodak's winning formula of making photography simpler, cheaper and more ubiquitous[38]. In a revolutionary move, the traditional film was replaced with a disc, which had 15 exposures radiating like broad spokes from its center. The disc was rotated by a minute electronic motor inside the camera. One advantage of the disc was that it aided focusing by presenting a completely flat slice of film for exposure. It also allowed for an extremely thin camera; it was about the thickness of a cigarette case. The flat plane of the film also reduced the distance between the film and the new four-element glass lens. That improved depth of field and permitted flash

[38] In 1963, when the cartridge loading 126 Instamatic cameras had been introduced, many had predicted that it would mean the demise of much of the quality camera market because it made photography so easy. In fact, the opposite happened. By introducing photography to millions of new people, the 126 easy cartridge load system and its follow-up, the 110, created immense new interest. Many

pictures as far away as 18 ft (the old standard was 10 ft). Kodak also doubled the film speed without compromising quality. And the "calculator-type feel" of the shutter button -- which was pushed toward the user – tended to reduce blurred pictures (Verespej, 1982).

The film emulsion was revolutionary as well. The emulsion contained light-sensitive particles of silver nitrate – itself not unusual – but the Kodak particles were particularly finely grained. This implied that it had more light-sensitive 'dots' per exposure. The company's pocket Instamatic-110 camera had about 2 million dots in a picture; a disc picture had 3 million dots. By contrast, an electronic imaging device like the Mavica, which stored its pictures on a 3.5 inch floppy, had only 280,000 dots. The disc images were of the highest quality available at the time. The new Kodak film was also faster--its chemicals reacting more quickly to light--than that used in Instamatics and many other cheap cameras. This reduced the risk that a blurred photograph would be caused by camera shake. The Kodacolor HR disc film for use in the extremely small (approximately 8x10 mm) format had lower granularity with more sharpness than the current 100-speed Kodacolor II film, regarded at the time as the premier achievement in color negative film.

The entire disc camera was managed by a microprocessor, which controlled focusing, rotated the film disc and operated the built-in, automatic flash unit. It was powered by a lithium battery, which lasted for about 25 discs. Also, Kodak went back to using a glass lens, instead of plastic, dramatically improving focusing quality. The lens, which Kodak described as being "near the theoretical limits of perfection," contained four glass elements (*Newswire*, 1982). The format also permitted the design of cameras that fit easily into a shirt pocket with efficient components that made minimum demands on the energy source.

Kodak disc cameras and the accompanying Kodacolor HR disc film supposedly reduced the chance of underexposure by half, camera shake that results in blurry pictures to less than two percent, and the number of blank frames and flash failures to less than a fraction of one percent (*Newswire*, 1982). At the same time, the yield of "good to

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of those who bought cheap Instamatics went on to become enthusiasts, buying more expensive precision equipment. The result was that photography boomed in the late 1960s and 70s.

excellent" pictures, if one were to believe Kodak's numbers, increased by 25 percent. Experts agreed that the new cameras were "the most electronically sophisticated in the company's history and combined with the new film can produce a higher percentage of good to excellent pictures over a dramatically wider range of picture-taking conditions" (Newswire, 1982). Kodak described their new cameras as "pocket-size, precision instruments" that were truly decision-free and always ready to take a picture. At the touch of a button, the cameras, by means of two integrated electronic circuits, in a split second, analyzed the scene, set the proper exposure, activated the built-in flash if necessary, took the picture, advanced the film to the next frame and recharged the flash.

The cameras and film were accompanied by an extensive line of photofinishing equipment to handle the new disc film. The line ranged from fully automated high-output equipment for high-volume labs to smaller, manually operated equipment to meet the needs of the smallest lab.

Poised for Dominance

The moment it was announced, the disc camera system was poised for dominance. *The British Journal of Photography* wrote in its 1982 editorial:

> The cameras are the lightest and most pocketable so far made and success is predicted worldwide. Unlike the cartridge systems it is quite possible to make precision disc loading cameras to interest the upper sections of the market. There is the difference that, whereas the Instamatics were introduced at a time of affluence in the developed world, the film disc arrives at a time of recession. Nevertheless, its appeal is so great that it is expected to carve out very rapidly a place as the leading camera type in the snapshotter market at least. Another point is that it has a pocketability and convenience which electronic solid state still cameras [35mm] cannot possibly hope to achieve in the foreseeable future and by that is meant more or less for the rest of the century. (*British Journal of Photography*, *Annual Issue*, 1982: 21)

There was a consensus that amateur picture-taking had taken a "substantial leap forward" in automation and improved results with Kodak's new disc cameras. Walter Fallon, Kodak's CEO, maintained that the disc photography system would make millions of people better photographers then they could have been before. "It's truly a technology for the 80's. That these cameras combine extremely advanced features and capability at an affordable price is a tribute to Kodak's constant efforts to increase productivity, simplify manufacturing, and still advance the state of art," he stated. (*Newswire*, 1982)

Industry Week concurred:

> With a quantum technological leap, Eastman Kodak Co. has given the pocket-camera industry the boost it has sought for three years. The Rochester, N.Y.-based firm has also sent its competitors out to play catch-up.... There's a virtual consensus that the new camera -- 1 in. by 3 in. by 5 in. in size -- has already remade the business -- without a single sale." (Verespej, 1982)

"Put it this way," stated Ronald L. Walsworth, president of Berkey Photo Inc.'s film-processing division, White Plains, N.Y., "anyone who buys a pocket camera above $40 will buy a disc. That's new disc-land." (Verespej, 1982)

Verespej expected the disc cameras to

> [G]ive rocket-like impetus to sales, which have slumped 30% from a high level of 10.2 million in 1978. Despite a short-seven-month selling season from the time they hit the marketplace in mid-May to Christmas, analysts predict the U.S. sales of between 4.5 million and 6 million for the three models. That compares with 7 million pocket cameras sold during all of last year and 3 million first-year sales of Kodak's pocket cameras ten years ago. The number of pictures taken by amateur photographers is expected to leap 10% to 20%.(Verespej, 1982)

The reasons, Verespej of *Industry Week* suggested, were simple:

> The technological changes will dramatically increase the percentage of good-to-excellent pictures from 75% to 95%, and that's most important with point-and-shoot photographers." (Verespej, 1982)

Eugene Glazer, analyst with Dean Witter Reynolds Inc., New York, agreed. "Once the consumer sees this, it'll knock out any thought of buying any other pocket camera," he asserted. "The impact is going to be pretty dramatic, despite the negative economy." The camera's technological capabilities "will allow consumers to take pictures in almost any situation with very high reliability," added Peter J. Enderlin, photographic analyst with Smith Barney, Harris Upham & Co., New York. "The disc system comes closer than any other photographic system ever offered to totally foolproof picture-taking." Brenda Lee Landry, Photographic analyst with Morgan, Stanley & Co., New York, observed, "In low-light situations -- a bride at the altar or a basketball game -- where the consumer really wants a great picture, the camera really shines... Other camera makers are going to have to go back to the drawing boards" (Verespej, 1982). Mr. Glazer was quoted as saying, in the same article, "there are certain technologies -- like the lens -- that might be difficult to duplicate. It gives Kodak at least a one-year head start over its competitors" (Verespej, 1982).

"Production methods for the lens, for example, are so proprietary that Kodak won't even discuss them," noted Smith Barney's Mr. Enderlin. He and others expected the competitors would need at least one year to copy the camera, and perhaps 18 months to achieve similar breakthroughs in film. While Fuji and Konishiroku (Konica) both intended to have a go at producing disc films, it was commonly recognized that they would have their work cut out. It took Kodak eight years to develop its new product. It took its laboratories five years to reverse engineer Polaroid's Instant picture film when that came out.

Commercially, the new film format was intended to help Kodak maintain its hold on the lucrative color-film business where pre-tax profits were a fantastic 50-60% of sales. These profit margins were enticing firms like Japan's Fuji Photo Film and Konishiroku into competition with Kodak. Film sales, together with film and copier paper, provided 20% of Kodak's sales but 60% of its pre-tax profits. So Kodak was naturally eager to hang on to its dominating share of the market--90% in America. Kodak's monopoly on film for the new camera was also to be reinforced by the need to have special processing equipment to develop the pictures. Film-processing companies had to either buy this relatively expensive equipment from Kodak or hand over their business to Kodak's own facilities.

Securities analyst Thomas D. Henwood, of First Boston Corporation considered the new HR film a key to the potential success of the disc cameras and to Kodak's ability to withstand any attempts by offshore manufacturers to cash in on its new system. Henwood maintained that it would be "a year or two before the offshores can commercialize the technology" in the new film and "longer until they can make the disc." He believed that, if Kodak eventually made HR-type film available for 110 cameras, this "will help makers of higher-priced 110s such as Pentax hang on." If not, "characteristics of 110s" and smaller 35mm cameras "become less attractive," Henwood said. "Anyone who has a lot of 110 cameras is going to want to dump them." (Gross, 1982)

He had one word for the disc cameras--"super"--and cited with more than casual approval "Kodak's ability to invest somewhere around $700 million to generate a 35 to 40% average return within two or three years. The annual rate of return will peak in five or six years," Henwood predicted. "By then, others can duplicate the emulsion system, but not necessarily the entire system and pricing." (Gross, 1982)

Launch

The disc camera's launch was supported by the most extensive television advertising campaign in Kodak's history. Introductory commercials for disc products appeared on prime-time TV throughout the nation for months. Its marketing was praised by industry analysts and even marketing gurus. Writing in the *Harvard Business Review*, for instance, Quelch and Bonventre (1983) commended Kodak on its point of purchase marketing strategy in the case of disc technology, highlighting the rotating display unit that presented the disc story to the consumer without the need for salesperson assistance. Further, they admired the merchandising aids, sales training and meetings for retail store personnel, film display and dispenser units, giant film cartoons, window streamers, lapel buttons, and cash register display cards that were part of the campaign (Quelch and Bonventre, 1983).

Kodak's marketing and its enormous clout resulted in an enormous response for disc cameras. Before the camera was even launched, nearly 1,100 independent photo labs, 350 of them in the United States and Canada, already had ordered finishing equipment to process film for Kodak. CEO Colby Chandler reported that dealer orders also were "running above the high levels we had anticipated" for disc cameras (*Newswire*, 1982). And indeed, the technology was extremely successful. In the first year of sale, Kodak sold more than 8 million disc cameras in 1982, practically a six-month year. In fact, industry sales of cameras broke a new record. Total color negative exposures in the U.S crossed the eight billion mark -- another record. Total traditional exposures, including black-and-white film and color slides, made a six percent gain over 1981 to about 10 1/2 billion. The general manager of Kodak's Photographic Marketing Group called these records "a standout performance" in a year of generally sluggish economic activity. (*Newswire*, 1983)

At year-end, U.S. photofinishers were reporting that disc accounted for 10 to 15 percent of their color negative volume with many expecting it to be at 20% within months (*Newswire*, 1983). There were twice as many disc exposures in 1982 as there were 110 exposures in 1972, the year Kodak pocket Instamatic cameras were introduced. The disc camera's phenomenal success was attributed to the technological design which, according to Vice President J. Samper (speaking at a NY city press conference) "met the needs of picture-takers" in what Kodak called the "automatic" user market, those who mainly want a convenient way to record their memories. According to Kodak's market research, some two-thirds of camera owners in the U.S. fell into this category. As proof that the innovation of disc cameras and film were both meeting the needs of consumers as well as expanding the photographic market as a whole, Samper cited Kodak surveys among more than ten thousand disc camera owners in which one of every two respondents indicated that they would not have purchased a camera when they did if the disc system had been unavailable. (*Newswire*, 1983)

Indeed, some people were already jumping on to the disc bandwagon. Just a year after the introduction of Kodak's disc camera system, three other film manufacturers announced that their very own 15-shot 8 x 10 mm frame size color print film discs would begin to roll sometime in 1983. Joining the list were 3M, Sakura (selling as Konica) and Fuji. (Schwalberg, 1983)

Popular Understanding of Disc's Success

Disc technology's instant success was naturally attributed to Kodak's uncanny ability to meet customer needs through superior technology. The market had already shown its appreciation; experts conceded its greatness too. In a test conducted by *Popular Photography* to ascertain the quality of photos produced by disc cameras, the professionals/writers concluded that "the grain and sharpness comparison resembles that of their respective ISO 100 35mm siblings, Kodakcolor VR100 and Fujicolor HR 100."

The superior technology behind the disc camera was also acknowledged by Consumers Digest. Indeed, Kodak was one of the eight companies – selected by a nation survey for their responsiveness to consumers' needs – which were presented with the first annual *Consumers Digest* "Hall of Fame" Awards[39]. The ceremonies were keynoted by Virginia H. Knauer, special adviser to the President for consumer affairs who lauded Kodak for "the development of the disc camera 'decision-free' system, permitting still greater reductions in the size of the pocket camera without loss of picture quality." The *Consumers Digest* "Hall of Fame" Awards were created to honor those companies "responsive to consumers' needs for improving the quality of their lifestyle," said Arthur Weber, founder-publisher of the Chicago-based magazine (*Newswire*, 1984)

Later that year, Kodak received the I-R 100 Award for development of the Disc Camera. The I-R 100 award is granted in recognition of the most significant

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[39] *Consumers Digest* readers were surveyed by mail ballots which cited four companies in each of eight categories. These companies were selected by editors of leading trade publications and recognized

technological developments of the year. The I-R 100, sponsored by *Industrial Research & Development Magazine*, is awarded by a panel of nonpartisan judges from the technical and scientific community. At the occasion, Frank Strong, vice president and general manager of the company's U.S. marketing division stated:

> The disc program represents an example of how research and development can translate directly to consumer benefits. In addition to greatly simplifying picture-taking, the disc system offers consumers a substantial increase in the number of good-to-excellent pictures they take, when compared to previous cartridge-loading systems. (*Newswire*, 1983)

Applying research and development dollars to serve clear consumer needs has long been a Kodak tradition," Strong observed. As another example of the disc system's acceptance, Strong pointed out that a number of photographic firms have licensed Kodak's technology to market their own disc equipment. "Disc is well on its way to establishing itself as one of the most popular amateur picture-taking systems ever," he commented. (*Newswire*, 1983).

Similarly, Kodak Chief Executive Walter A. Fallon, who led his company's pioneering effort in disc photography, was awarded the Henry Laurence Gantt Medal[40] for distinguished achievement in management (primarily for disc technology). Former U.S. Commerce Secretary Juanita Kreps presented the 1982 Medal to Fallon at the 54th Annual Human Resources Conference of American Management Associations, which co-sponsor the award with the American Society of Mechanical Engineers. Kreps listed the strides made by the company with Fallon at the helm. She said:

> At a time when many wondered about the ability of any mature American company to vitalize its technology to stave off foreign competitors, Walt Fallon's Kodak has been moving ahead on many fronts:

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experts in each field. Ballots were tabulated by the Ernst & Whinney accounting firm, the only people to know the results prior to the awards presentation.

[40] The award, named after the renowned management consultant who died in 1929, is widely regarded as the most prestigious honor an American businessman can receive.

in laser technology, in biotechnology, in chemistry, optics and electronics. It was under Fallon's leadership that Kodak gave the world the new Disc Camera -- *the company's most significant new product in two decades and one of the most important products in Kodak history.*" [italics added] (*Newswire*, 1983)

Early reports and analyses of the disc camera confirmed two things: the quality of images produced by this camera was as good as those produced by the 35mm format[41]; and in terms of ease of use, these cameras were the simplest available (they were essentially, as Kodak claimed, 'decision free'). Indeed, it was widely acknowledged that disc cameras represented the state-of-the-art in photographic technology. However, one crucial difference was that while 35mm was not controlled by anyone, disc technology was proprietary to Kodak. This had important implications for the networks that could form around the two technologies.

DECLINE OF THE DISC

The meteoric rise of the disc camera reached a plateau in a single year (reaching a high of 5.1 million units in 1983) and then began a steep decline (Figure 6.3). In 1988 the market share of disc cameras had fallen to 5.6% while 35mm point and shoot cameras represented 42.1% of the market (in 1987 these numbers were 9.6% and 34.2% respectively; while in 1985 these were 27% and 22% respectively).

Figure 6.3 About Here

The annual report of the Photo Marketing Association pronounced the disc as a has-been in 1987, arguing that "despite great expectations, the reception of the disc was less than enthusiastic." (*PMA Industry Trends Report*, 1987) Such a conclusion was

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[41] Indeed, since Kodak is the undisputed leader in film technology (in every format) it is not hard to believe their claim that disc technology allowed them to go beyond the quality they could achieve in 35mm.

blatantly exaggerated since in September of 1986 Kodak produced its 25 millionth disc camera. And as Kodak itself claimed, any product, which sold 25 million units, could not be labeled as a failure. It was estimated that competitors such as W. Haking Industries of Hong Kong had sold millions more (Feder, 1988). However, sales for Kodak itself never approached the 12 million to 14 million units a year for which Kodak had built capacity. Sales peaked within two years of the camera's introduction, and then continued downhill. Consequently, the Eastman Kodak Company suspended the production of its disk camera six years after its introduction, due to declining demand and excess inventory.

Popular Understanding of Disc's Failure

Popular opinion among analysts was that the disc failed because photographers were never completely satisfied with the relatively grainy pictures that were produced by the 8-millimeter-by-10 millimeter film frames, especially when they were made into enlargements. Improvements in the film did not resolve the complaints. It was suggested that the camera's future had looked steadily dimmer as 35-millimeter cameras, including several made by Kodak, became cheaper and easier to use. The disk-camera's market was also squeezed by the unexpected continuing popularity of 110-format cameras[42], which are less expensive. Kodak's cheapest 110 camera, for example, listed for $30.70 and was often substantially discounted, while the least expensive disk camera listed for $44.95.

A myriad of reasons were cited for the failure of the disc camera. For example, popular photography, which had concluded earlier that the quality of disc pictures was no worse than those produced by 35mm cameras, now suggested that the decline of the disc was "because the increasing popular compact 35mm cameras offered far superior picture quality to the point-and-shoot photographer. Joseph Runde (Public Relations Manager for Kodak) added: "Disk cameras were definitely easier to use, but at the same time the point

[42] In 1987, about 1.8 million disc cameras were purchased, compared with 7 million Easy-to-use 35mm cameras and 6 million 110- and 126-format cameras, said Ted Fox, director of marketing research for the Photographic Marketing Association in Jackson, Mich.

and shoot manufacturers made film loading much easier for people. And substantial improvements were made in the image quality of P&S cameras[43]."

The April, 1985 issue of *MacLean's* magazine argued that the quality was not to blame, but it was the highly sophisticated nature of the disc that did it in:

> The tiny, shirt-pocket-sized camera, which uses a negative one-ninth the size of its 35-mm counterparts, was intended as an alternative to the company's conventional cartridge-loaded snapshot cameras. But the camera ran quickly into marketing problems. For one thing, many consumers found that the tiny negative used by the disc camera produced grainy prints of inferior quality. *The company eventually corrected that flaw by improving the camera's film.* But the camera's sales also suffered because of its sophistication -- compared to the simple plastic boxes it replaced -- and the U.S. dollar's rising value pushed its price on export markets into the range of highly automated 35-mm cameras. As a result, Kodak's annual production of disc cameras is about five million units, far below the firm's production capacity of 14 million units a year. [(Austin, 1985: 36) [italics added]

Andy Grundberg, writing in the *New York Times* of April 8, 1990, belonged to the group who considered disc quality worse than 35mm. However, he conceded that Kodak had all the means to better existing standards of quality in the marketplace and suggested that the disc was deliberately bad:

> Kodak was preparing the world for the era of still-video pictures. By reducing the size of the negative, Kodak also reduced the quality of the print. With the Disc format, the resolution got to be so bad that the print looked like a fuzzy picture on a television screen. Ipso facto: get everyone used to pictures that look like television images, and they'll be primed for pictures that essentially are television images. (Grundberg, 1990:58).

[43] Interview with author.

As long as sales were increasing, nobody questioned the quality of disc photos. In fact, all tests showed there to be no discernable difference between the quality of photos from the two formats. It is true however, that smaller formats[44] tend to yield more grainy photos because of the need to enlarge, but as the *MacLean's* article stated, "Kodak had bridged the gap between the two formats by introducing new, much improved films for the disc cameras. Kodacolor VR Disc Film which replaced the earlier Kodacolor HR Disc film in October 1983, represented great refinements in the original technology that enabled development of disc film and later led to the very successful introduction of Kodacolor VR 35mm films." In the same article, Frank Strong, a Vice President at Kodak said that improvements in grain throughout the exposure range as viewed in prints were achieved by modifications to the protective overcoating above the emulsion and to changes in the antihalation backing. Gains in sharpness, especially noted in bright outdoor scenes and close-up flash pictures, were attributed by Strong to a new thinner emulsion in the yellow layer, a thinner magenta layer, and by incorporating new DIR technology. Strong also cited a new magenta coupler which provides improved keeping of unprocessed film. Overall contrast of the film was increased to provide more snap in prints. Strong emphasized that Kodak surveys of more than 20,000 Disc Camera owners showed that over 90 percent are either satisfied or very satisfied with their cameras. "Of particular appeal is the ease of use and convenience of the camera as well as the fact that virtually all of their pictures turn out," he said (*Newswire*, 1983).

In my investigation into the demise of the disc camera, it appeared clear that all the popularly cited reasons for it pertained to the technology itself. It was assumed that the 35mm and disc format could be compared on an absolute basis. Specifically, one attribute was cited over an over again: quality of the photo. Nobody cared to look beyond the inanimate technology into the realm of stakeholders to see how this technology and the basis for evaluating it were actually constructed. Nor did anyone look into why

[44] The APS format, currently popular in the photographic industry, is much smaller than the 35mm, and does result in slightly poorer pictures, but the issue has not been raised at all in its case, since all major 35mm manufacturers are behind this new format.

certain issues were raised, such asthe quality of disc photos, while others were not such asthe much smaller and thinner, and hence easier to carry, disc camera.

WHY DID THE DISC FAIL? AN INVESTIGATION

Since almost all explanations of the disc's failure blame the poor quality of the film, it is appropriate to begin our investigation from this point. In particular I will examine how the quality of disc photographs was constructed, and why Kodak, with its enormous clout, was not able to construct a network around this technology.

Influences on Quality of Disc Photographs

It is illustrative that while during the disc's introduction and meteoric rise, all analysts seemed to agree on its technological superiority, even brilliance, in a couple of years, everyone was blaming the disc's technology for its demise. However the superior or inferior quality of photographs was not an inherent attribute of the camera/film system, but one that was constructed at least partially outside the technological domain. Quality was composed of several different aspects of the technology as well as the consumption chain. The failure of the disc system shows that quality of a photograph is affected by functional attributes not only of the film, but those of the camera, photofinishing processes and the cognitive framework of the consumer as well. Below I elaborate on this by discussing some aspects of quality pertaining to film, camera and photofinishing.

Film

While it is commonly claimed that no means of representation is as innocent, as scientific, as the photograph, yet, everytime we look at a photograph, we are aware, however slightly, of the photographer selecting that sight from an infinity of other sights. Moreover, there are facts that go beyond the predilections of the person handling the photographic apparatus to the ideologically charged nature of the apparatus itself. Photographs, cinema and television do not merely express in texts the ideology of the culture that produces them, with the possibility that other ideologies could equally easily be signified in different texts; rather the technologies are embedded in the social sphere and are themselves an ideological expression of the culture.

Accordingly, contrary to popular understanding, there are no completely objective criteria to judge the quality of color films. Indeed, as with all technological artifacts, the social context in which the film is designed, produced and used interact intimately with the technology to give it its meaning. For instance, the most superior color film does not completely represent skin color accurately. Essentially the research agenda for color film was dominated by the need to reproduce Caucasian skin tones. This need conditioned the ways in which the technologists thought about the competencies made available to them by science, and how they transformed those competencies into actual film stocks.

Winston (1999) has argued that color films more readily photographs Caucasians than other human races. The color film is a cultural creation. Colors are formed by chemicals known as dye-couplers. The choice of dye-couplers by the chemists designing a film stock will determine the sensitivity of the final product to different lighting conditions and different colors. A paramount consideration in this decision-making process is the ability of the final stock to render white skin in a culturally, and therefore commercially, acceptable manner.

All professionals fully understand that color films, despite continuous improvements in performance, do not render dark skin tones as easily as they do white. They know for example that, when filming subjects with dark skin, it is often necessary to augment lighting by bouncing reflected light back into the face from a low angel, for instance, so as not to lose details. Were these stocks to offer a "direct…registration of color in the natural world," we could simply attribute the difficulties of filming black people to a natural racial disadvantage – somewhat like, say, sickle-cell anaemia. But color film, and color television systems, do not directly register the world. As the comedian Godfrey Cambridge once hyperbolised – but only slightly – African-Americans look green on American (NTSC) television; no amount of knob-twiddling changes their color (unless one makes the whites orange); and he for one was not surprised. The history and ideological implications of these technologies - technologies created by whites which best reproduce Caucasian skin tones - offer a good case study in technological agenda-setting at the stage when a technology is transformed from idea to existence.

At one level it is 'inevitable' that the bias of color film should be the way it is. After all, according to Kodak, more than 8 billion color negative exposures were made in the U.S. alone in 1982, and the vast majority of them were by and of whites. But the rhetoric surrounding color film, as much in the technical and scholarly literature as in advertising and other popular accounts, implicitly denies any such partiality in favor of a stress on naturalness, realism and verisimilitude – mathematics, as it were, rather than painting.

The technological reason is simple and lies in the three color method that is the basis for all current color reproductive methods, photographic and electronic. By 1807, Thomas Young had established that the cones of the retina, those photoreceptors sensitive to color, were of three types, the rho, (responsive to red-orange-yellow), the gamma (orange-yellow-green-blue/green) and the beta (blue/green-blue-violet). If Maxwell's filters or any dyes used in a photographic process, triggered only one of these cone-types as appropriate, then the pattern of stimulation caused by viewing the reproduction would exactly agree with the original stimulus.

Unfortunately, no filter can be found which will activate only the gamma cones. Wherever green appears there will be an excess of beta and rho cone stimulus that will render greens paler and, although scarcely noticeable in the reds and blues, will also cause whites to acquire a magenta tinge. Increasing the intensity of the red and blue lights or dyes restores the white but at the cost of distortion in the relative chromatics and intensities. Suffice it to point out that this is not the only method of capturing color, but simply the most prevalent one. The discourse surrounding quality of film is thus situated in a cultural space ruled by normative and cognitive institutional understandings and expectations.

Even when we grant that since almost all films share this tendency and thus neutralize each other in this aspect, quality is still not a simple construct to measure. For instance, in a 1983 test conducted by *Popular Photography* magazine, the testers had this to say about color and contrast of Kodak and Fuji films:

> I like Fuji – its brighter, brasher, more sparkling. Printer Perez favors Kodak, opining, 'Kodak's colors are much more natural, Fuji's are

brighter, almost fluorescent. Most amateurs will probably prefer Fuji's color, especially in small prints.' In fact, we found that Fuji disk film has higher yellow saturation, while Kodak leans more toward the magenta. (*Popular Photography*, September, 1983: 59).

While normative and cognitive institutions are instrumental in the development stage of a technological artifact, they are also equally crucial in the use stage. For instance, the quality of a photograph is popularly thought to reflect how accurately a camera has been able to capture an object. And this is indeed how the scientific community understands and socially constructs quality. However, ordinary people perceive quality quite differently. For instance, when Fuji's market share continued to increase at the expense of Kodak's, the latter commissioned market research which showed, much to their astonishment, that consumers preferred colors that were *not* accurate! Fuji's colors were unnaturally bright and over-saturated (the Greens are greener, reds redder) compared to Kodak's which were more *real*. Fuji never had a problem convincing customers of its high quality. When Kodak realized that consumers wanted Fuji's supersaturated colors, it introduced its VR-G line of films. From a sociological perspective, it is not difficult to explain this phenomenon. As we discussed in the Polaroid case, the subjects of photographs are determined less by individual consciousnessthan by a social process where certain images are considered socially sanctioned and desirable. Thus, the image of a family, as depicted in popular commercial discourse, is that of a happy one -all smiles and no conflicts. Such an image is enacted by people through photography in the case of individual families. Supersaturated colors, while unreal, lend a sense of optimism, glee and general happiness to photographs, creating the desired effect.

Here we will not go into a discussion of whether 'quality' really drives sales or not. For that discussion, refer the Polaroid case (Chapter 5).

Camera

Quality of a photograph is also determined by features specific to the camera. Following are a just a few, more commonly known aspects of cameras which affect the quality of a photo:

Focal length of the camera/lens.

Film speeds available (not every camera type has a variety of film speeds available; action is captured better through faster films, with higher ISO ratings)

Focus zones (More zones generally mean better focusing)

Synchronization of flash and shutter

Low-light ability

Flash uniformity (How evenly the flash lights up the scene)

Flash range (the max distance that you can expect the flash to illuminate effectively)

Exposure accuracy (how capably a camera adjusts its shutter and aperture to match the light level)

Smallest field (the width of what you see when the camera is focusing as close as it can; the narrower the field width the better the camera for close-ups)

There is no question that no single organization is responsible for improvements in all these aspects of camera design. And naturally, just as in the case of film, all these aspects are also imbued with social understandings, assumptions and constraints. All these social aspects of the hardware provide opportunities for proponents of technologies to build, modify and control discourse around the superiority of technologies. Thus, at any one point in time, several aspects can be raised about a camera: its weight, size, ease of use or technical sophistication. Similarly, the quality of a photo can be described in terms of colors, realism/accuracy or ability to shoot in low-light situations and so on. Finally, quality is also determined by aspects of photofinishing. For instance, we discussed how photofinishers found it difficult to deliver a high quality set of prints given the design limitations of disc cameras.

Finally, features that did not affect quality but simply the operation of the camera were important in the discourse-development, too. For instance, how a camera handled film - how conveniently a camera helps advance and rewind film); whether a camera had autofocus capability or prevented distortion ;how well they reduced red-eye; how friendly they were to eye-glass users;if they used normal alkaline or lithium batteries and how light-weight or small to carry around were considerations which were all emphasized or de-emphasized periodically by firms.

Photofinishers and Dealers

The process of creation of disc technology did not end when the end product came out of Kodak's manufacturing facilities, all neatly packed. It continued in the backs of dingy labs, on shop counters and in the consumers' homes. Contrary to Kodak's understanding, it was not the only player constructing the discourse around disc technology. Perhaps, it was not even the most important player in this constructionist process! Everyone who was in any way connected with this technology was involved in this complex process. From those whose interests were threatened by it (photofinishers who could not afford to invest several thousand dollars to acquire the new photofinishing equipment; 35mm camera and film manufacturers) to those who stood to gain from it (Kodak; licensees; retailers; photofinishers with required equipment and expertise).

With any radically new technology, proponents have three choices: take the constraints of their existing network into consideration when designing the product, enroll new stakeholders who stand to gain from the new technology, or internalize the new manufacturing (like Polaroid in the case of SX-70). However, by abandoning the existing network in favor of a new one, proponents cannot hope to eliminate the former from the process of construction of the new technology (they have alternatives such as supporting an alternative technology or undermining the present one). When the disc was introduced, the institutional field consisted of several overlapping networks which included all organizations associated with the design, manufacturing, selling and servicing of cameras and film built around the 110mm format, the 35mm format and Instant technology. While the 110mm format and Instant technology represented somewhat static or diminishing clusters, primarily because of their proprietary nature, 35mm was dynamically evolving with innovations occurring in all its aspects including camera design, film quality, photofinishing and so on.

The disc was not competing only against some abstract notion of customer needs, but also against the strengthening 35mm bandwagon. To create a bandwagon of its own, Kodak needed the support of the institutional field. However, it demanded this support on its own terms (opting to merely license the technology rather than allow competitors to clone), subjecting them to perpetual existence at Kodak's mercy. Much like when Polaroid made its own technology obsolete with the SX-70 and its supporters were left in a lurch, Kodak's would-be supporters always had this fear in the back of their mind. As long as Kodak could demonstrate growing support in the market for the new design, they went along, but none of the more established camera manufacturers entered the fray, opting for the open 35mm architecture instead.

The disc camera was essentially wallet-thin and took a disc rather than a film roll. There were several ways in which it differed from existing designs. First, the disk itself was a novelty with which both consumers and other stakeholders, especially photofinishers, were unfamiliar. Manufacturing discs to the required specifications was difficult - it had taken Kodak eight years to develop the system - and others had to rely mostly on reverse engineering. Developing pictures from this medium required substantial investment in new photofinishing equipment, which most small labs could not afford. As a result, they sent the discs to bigger labs, resulting in delayed delivery. Moreover, the introduction of a new medium for capturing and storing images disrupted the existing routines that had been established by photofinishers thus resulting in loss in efficiency. Thus, photofinishers did not find this alternative too attractive.

The design of the disc camera, while state-of-the-art did not reflect any consideration on Kodak's part for the photofinishers. In an open letter published in *Photographic Trade News*, photo industry consultant Jerry Lansky described the development process for the disc, noting:

> It was so different from anything we had handled in production before: exceptionally tiny chemical tanks that were hard to keep in balance, special disc opening technique, printing frames that were so tiny

they were impossible to preview, unusually heavy paper waste because it was inconceivable that a printer person would hit it on the first pass, and a different packaging routine. (Lansky, 1995: 28)

As a result, with most people having to retrain themselves to handle the new medium, the prints did not turn out as good as they did in the tests, where ideal conditions were present. Thus Lansky noted:

> All of this might not have been so bad... if we were proud to deliver a good set of quality prints. I'll be kind: the prints were merely horrible. With our best efforts, the high expectations for disc came crashing down as did our morale. As we got turned off we would shudder whenever a customer dropped a disc on the counter. As destructive as it may have been to us and our investment, our counter people were frustrated ... and since we didn't want to take the rap as being bad processors, we bad mouthed the disc.
>
> At the time... on-site equipment represented maybe less than five percent of all the rolls being processed in those days. But I bet we did more than our share to undermine disc for one primary reason: we had to talk to the customer face-to-face. It took longer for Kodak and the wholesaler to get the negative response to disc that we were hearing because they were once removed from the shooter. The star fizzled. (Lansky, 1995: 28)

Kodak's ultra-secretive policies did not help the situation either. The *British Journal of Photography* had hinted at the uncertainty that photofinishers were faced with before the technology was launched while maintaining that "although this feature is written before the large scale introduction of the camera, there should be no doubt as to its eventual popularity":

> The one group who could view this innovation with distrust are the processors. To be faced with a possible expenditure of over 100,000 pounds sterling just to get into the game on an economic level, does not, to most firms, seem an attractive proposition when equated with a possible 10% increase in films received. (*British Journal of Photography*, 1981)

To top it all, Kodak never really considered photofinishers or other smaller stakeholders crucial to the success of its products. Indeed, as a 1988, New York Times article stated:

> [I]f any one word could have described Kodak's old culture, it would have been insular...Kodak's world was bounded by its Rochester headquarters. It was international in the sense that up to 40 percent of its revenues came from outside the United States. But as far as Kodak was concerned, the only worthwhile ideas or processes were those that originated within its labs and offices.
>
> ...Kodak was almost pathologically secretive about its technologies. It rarely bought anything from outside suppliers, partly because it did not trust them to provide the quality the company wanted and partly because it did not want to give away trade secrets. After all, if you let an outsider provide parts, you must first provide it with a reasonable idea of the final product those parts will be used for. "Kodak didn't trust others, at first for good reasons, later for ostrich reasons," said William F. Fowble, vice president of manufacturing.
>
> ...Over the years, research, design and manufacturing executives developed an inordinate amount of power at Kodak. They guarded their fiefdoms jealously, and respected each other's turf. And, they called the shots. If research wanted to spend an extra month, even an extra year, coming up with the perfect product, no one raised a voice in protest. "We used to brag about how long it took us to work on a product," recalled one long-time Kodak veteran.

...Its provincial attitudes spilled over into its marketing. "When we came into this market in 1970, Kodak just wasn't merchandising film," recalled Thomas H. Shay, a spokesman for Fuji Photo Film USA Inc. It was Fuji, not Kodak, that introduced the concepts of multi-roll packages of film and of huge, colorful point-of-sale displays. Kodak has followed suit, but it has never recaptured the 10 percent of market that Fuji managed to grab away. (Deutsch, 1988)

Kodak's bureaucracy and disdainful attitude towards smaller players discouraged any active enrolment. Indeed, several film outlets were becoming fed up with Kodak's marketing bureaucracy, and one of the largest chains, drug retailer Revco D. S. Inc., says it has approached Fuji with an offer to replace Kodak film entirely with the Japanese brand. "We have to go through heartaches that a retailer doesn't need" to deal with Kodak, said Marc J. Dworkin, Revco's senior vice-president of marketing. Aside from Kodak's refusal to grant volume discounts, there are various additional frustrations, Dworkin maintained.

Recently, he noted, Kodak tried to insist on supplying Revco with self-service film display racks six inches taller than the racks the company used for other products in all its 1,560 stores. Revco offered to make its own racks if Kodak would compensate it for doing so. But getting approval required intense negotiations, Dworkin maintained. Kodak marketing personnel, he said, were "inflexible and difficult."[45]

The reasons for the disc's failure, it seemed, lay not in the technology itself but outside it. While consumers obviously liked the technology and it fit well with the photography rituals, Kodak remained the sole force behind the technology. On the other hand, the open architecture of 35mm was attracting newcomers in throngs The 35mm camera was harder to use, still requiring some familiarity with controls, was more

[45] Dworkin was not alone in his complaints. In the Olympics incident (the organizing committee of the 1984 Los Angeles Olympics picked Fuji over Kodak as the official sponsor of the event, for the first time in history), Kodak had been the organizers' first choice, but they say they gave up after 20 months of frustrating nitpicking by Kodak officials over terms. Now the Olympics contract and the approach from

difficult to load, weighed more, was larger, and produced photos that were not discernibly better than disc photos- , . While the technology was not as popular among the consumers as the disc, the 35mm camera was much more attractive to players in the institutional field because of their non-proprietary nature and allowance for design modification.

Kodak's Weak Hold on the Photofinishing Market

Kodak's rather disdainful attitude towards dealers and photofinishers may have been because of its past dominance of this industry. In 1954, the markets for color film and color photofinishing were indisputably controlled by Kodak. Kodak had over 95% of the amateur color negative film market and did the photofinishing on all of its own color film because it controlled the technology and because its photofinishing was included in the cost of the film. A 1954 antitrust decree introduced competition into the photofinishing industry, both by barring Kodak from tying its film and photofinishing sales, and by requiring Kodak to license the technology and provide technical assistance to other firms that desired to enter the business. Indeed, as Kodak introduced new photoprocessing technology over the years ((i.e., photoprocessing for the 126 system in 1963, computerized automated printing in 1973) make as a footnote, independent photoprocessors were able to acquire the new technology and, because of the prohibition against tying and photofinishing, have the volume to use it. As a result, Kodak's share of the photofinishing market plummeted from 95% in 1954 to 10% in 1976, at which time there were more than 600 independent photofinishers in the United States (Table 6.1). While the loss of control over the photofinishing market diminished Kodak's power over photofinishers greatly, its imperious attitude towards them was taking longer to change. By the 1990s, however, Kodak had recovered its position in the photofinishing market through several acquisitions in the photofinishing market. Before that, however, 35mm technology had squeezed into the room provided by the antitrust decree rising rapidly in

Revco, which at the time sold $31 million of film a year, were the best possibilities Fuji had, even though it initiated neither opportunity. (I can't make sense of this last sentence) this period. The availability of 35mm minilabs only served to reinforce this trend. Further dispersing power in the industry, it made Kodak's job more difficult[46].

Table 6.1: Kodak's Hold on Photofinishing

Year	Kodak's Market Share of Photo-finishing	Comments
1954	95%	Consent Decree separating developing from selling film. Throughout the 1940s and 1950s, with the advent of color film, Kodak engaged in a practice of tying its film sales to its photofinishing services. Film was sold at a minimum unit price, set by Kodak, that included the cost of photofinishing. At the time, Kodak occupied a 95% monopoly position with respect to color film. By bundling the cost of film and processing, Kodak effectively monopolized the photo processing industry as well.
1976	10%	The 1954 Consent Decree dramatically changed the structure of the color photofinishing market. Pursuant to the Consent Decree, Kodak was enjoined from linking photofinishing tofilm sales and was required to make processing technology and materials available at reasonable rates. As a result, Kodak's share of the photofinishing market plummeted from 95% in 1954 to 10% in 1976, at which time there were more than 600 independent photofinishers in the United States.
1996	70%	The success of the Consent Decree was only temporary. Kodak has now recaptured more than 70% of the wholesale photofinishing market. Not surprisingly, Kodak's share of the color paper market has also improved. Kodak's dramatic recovery of market dominance in photoprocessing has been achieved principally by: (a) embarking on an aggressive campaign to acquire most of the once numerous independent photofinishers that had come into existence following the 1954 Consent Decree; and (b) using its traditional dominance in color film as leverage to induce retailers to accept Kodak's Colorwatch program, which offers discounts and advertising dollars

[46] The minilab does on-site photofinishing in about an hour. Because of their convenience these small labs expanded rapidly through the 1980s, and now account for about one-third of the photofinishing done in the United States. Macrolabs (including both wholesale and captive10 labs) have remained viable because they are somewhat less expensive per photo, but they have had to start providing faster service, and overnight wholesale service has become the norm. While there has obviously been an interplay between the different types of labs, each has its own niche. Macrolabs cannot provide one-hour service, but minilab costs per print are higher, and they cannot handle the volume of work required by large retail customers. Thus, retailers, such as department stores, food stores, and drug stores, use macrolabs.

		conditioned on exclusive use of a photofinisher that only utilizes Kodak color paper and color chemistry.

Sources: Fuji vs. Kodak, 1997; Berkey Photo vs. Kodak, 1979

Developing Time

Another problem with disc photography was the longer delay between dropping a disc off at a photofinisher and getting the prints back. Since most photo labs had been installing 35mm compatible minilabs for at least three years by the time the disc arrived, installing equipment to process discs was another expenditure, which few could afford. Indeed, the equipment for processing disc cameras and film represented the biggest equipment change since the introduction of 110 cameras and film. Despite Kodak's financing, several photofinishers decided to hold back and either use central labs or non-Kodak means for developing discs, before discs actually became the success everyone was expecting them to be. The result was not only poorer quality photos but also greater delay. This was especially significant because since the introduction of Instant photography, and one-hour minilabs, consumers expected shorter return periods.

Kodak's Social Engineering

Kodak is responsible for bringing about several institutional changes in the way people understand and carry out photography. For instance, before the advent of Kodak's advertising in 1888, argues West (2000), Americans were much more willing to "allow sorrow into the space of the domestic photograph," as evidenced by the popularity of postmortem photography in the mid-nineteenth century. Through the taking of snapshots, Kodak taught Americans to see their experiences "as objects of nostalgia, to arrange their lives in such a way that painful or unpleasant aspects were systematically erased." Similarly, Kodak influenced the emergence of new post-war roles for men and women through its advertising centered around the "Kodak Girl"; the successful, invention of the Brownie camera in 1900; the "Story Campaign" during World War I; and even the Vanity Kodak Ensemble, a camera introduced in 1926 that came fully equipped with lipstick. While at the beginning of its campaign, Kodak advertising primarily sold the fun of taking pictures. Ads from this period celebrate the sheer pleasure of snapshot photography--the delight of handling a diminutive camera, of not worrying about developing and printing, of capturing subjects in candid moments. But after 1900, a crucial shift began to take place in the company's marketing strategy. The preservation of domestic memories became Kodak's most important mission. With the introduction of the Brownie camera at the turn of the century, the importance of home began to replace leisure activity as the subject of ads, and at the end of World War I, Americans seemed to desperately need photographs to confirm familial unity. (West, 2000)

This new meaning that Kodak had created around photography was sustained by chemical-based imaging technology, all aspects of which Kodak dominated (until Polaroid began making inroads into its domination). The technology embodied the interests of several stakeholders who had gathered in the form of a field around it. Several routines, both technological and organizational, had formed around the technology, resulting in various efficiencies. The disc represented a technology within the same paradigm (preserving memories through cheap, easy to use cameras) but required a change in existing routines. The question was of efficiency and economic interest here, rather than a change in collective cognition.

That quality was an inherent attribute of disc technology was the presumption upon which Kodak seemed to be acting. Experts approved of the quality level and unanimously agreed that it was better than any of Kodak's earlier films. The tests that were conducted to establish the quality were obviously conducted in ideal conditions. However, in the market, with unwilling photofinishers, the quality produced was deemed unacceptable, especially when the benchmark was shifting up everyday (innovations in the open 35mm standard). Kodak then shifted its advertising stance to promote a 'different cameras for different needs' concept. However, 35mm cameras were already following a strategy of 'the same camera for different needs' bridging the functionality of expensive SLR cameras with the user-friendliness of cheaper, point and shoot models, while taking advantage of leaps in electronic technology. Moreover, since the standard was open, it was not up to the whims of one firm to change the whole system a few years later, thus rendering existing investments in equipment and learning obsolete.

The 35mm Network

As mentioned above, when the disc camera was conceived and about to be introduced, the photographic market was dominated mainly by three formats: the Pocket Instamatic (110mm), Instant photography and a rising 35mm format. In the amateur market Kodak had achieved unprecedented success with the Instamatic cameras selling about sixty million cameras over 12 years. Throughout this period, they had made photography simpler and cheaper, sometimes at the cost of quality (for instance the 110mm Pocket Instamatic took photos which were poorer than those taken by 126mm Instamatic). However, with time, films for 110mm format improved. Similarly, while Polaroid's SX-70 ($180, often retailing for $149) took pictures comparable in quality to 126mm and better than 110mm, its cheaper models were often not as good.

Finally, there was the 35mm format. In 1981, about 77% of all 35mm cameras sold were of the SLR type, and were bought mainly by serious amateurs. However, several Japanese firms were utilizing advances in electronics to produce new non-SLR 35mm cameras that were cheaper, smaller, more compact and yet exhibiting several of the functions typically the domain of SLR cameras. As the network of 35mm cameras spread, the trend towards smaller, friendlier cameras gained momentum. In 1983, the number of automatic (lens/shutter) non-SLR 35mm cameras surpassed the number of SLRs sold in this category[47]. Thirty-five mm cameras were now cheaper with increasingly better quality.[48]

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[47] The decline in SLR sales disproved a long-held myth in the industry that people like to graduate to more sophisticated cameras with time. In 1984, a Pentax study, for instance, (choose one: claimed that /indicated that) sales of SLR cameras were expected to increase beyond 1985. "As the industry turns to innovative marketing and advertising techniques that stress the simplicity of operation, supported by technological advances. Furthermore, a great many non-SLR users will be stepping up to 35mm SLR cameras for more sophisticated photography," said K. Chiwata, president of Pentax. The consistent decline in SLR sales, which continued to hold more features than ordinary cameras showed that people did *not* want more sophisticated cameras. In fact, the correlation was between higher income, regardless of an awareness of photographic technique, and SLR cameras.

Similarly, Masa Tanaka, president of Pentax maintained: "the determining factor in spurring SLR sales continues to be in educating first-time 35mm purchaser of the competitive features offered in today's SLRs and also in keeping prices competitive with non-SLRs. To this end, Pentax has increased its advertising budget significantly this year, with major emphasis on promoting our expanded SLR line,"

[48] Although quality was not necessarily the main reason why 35mm cameras were bought, as an article in the *The Washington Post* (March 19, 1978, Sunday, Final Edition; Style Travel; G5; "Good Photographs Can Be a Snap" by Carl Purcell) noted: "Tourists have been associated with photography from the time of Burton Holmes, the ubiquitous traveler who thrilled our parents and grandparents with lantern slide lectures on exotic lands and usually concluded his presentations with a hand-tinted sunset on some

The open standard of 35mm format posed almost no barriers to entry, apart from the capital-intensive nature of film production. Film in this format was freely and cheaply available, especially since Fuji's entrance into the market had depressed prices substantially. (Kadiyali, 1996) While Kodak dominated the market for 35mm film, 35mm camerascould be assembled with freely available parts in the market and sold under any brand name. The network surrounding this format spread quickly. Rather than being licensees, these firms marketed products under their own brands, developing technological capabilities in all aspects of imaging. Several innovations occurred in the design and technology of 35mm cameras as a result of the openness such as the autofocus lenses introduced by Minolta, and the infrared range-finding system introduced by Canon. Similarly, Fuji, Agfa and Ilford,as well as Kodak brought about several innovations in film, for example the ASA400 film which commands at least 40% market share of the total film market in Japan and allows for high-quality photography in low light and action situations. While all these innovations allowed players to build a competitive advantage for themselves, consumers were better-off because of all-around advances in this new format. Among the Japanese companies, patenting was not a primary strategy and this allowed these advances and innovations to diffuse rapidly throughout the industry.

The introduction of 'minilabs' in photofinishing business in 1977, when the first minilab was installed in the U.S, by helping the further diffusion of 35mms. (U.S.A v. Eastman Kodak, 1994). The advent of the minilab changed the structure of the photofinishing market, which had traditionally been dominated by wholesale

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distant horizon. We have come a long way both technically and artistically since the days when it was necessary to carry a camera in a suitcase and record images on glass plates. The compact 35 mm camera has made it possible for any traveler to record his own eyes and from his own point of view. Recent developments such as improved lenses, films and automatic exposure have made it much easier for the novice to get good pictures. The camera industry is booming and thousands of travelers are taking countless millions of pictures.

The 35mm cameras are a wise choice for travelers because of their small size and light weight. The best quality for the money are the Japanese imports, and there are two basic types. The least expensive is the fixed lens rangefinder camera, which is usually equipped with a moderatley wide-angle lens and automatic exposure. Some of these are available for less than $100 and they will handle most picture-taking situations very well. Used effectively for oudoror scene, individuals and small groups of people, they usually have a focusing range of about three feet to infinity. These cameras utilize a split-image in the view-finder for focusing and cannot be used for extreme close-ups. Of course, they do not have telephoto capability." (Purcell, 1978) photofinishing laboratories. Minilabs eroded economies of scale and dispersed power in the industry. Despite early resistance and skepticism in the industry towards the technology, minilabs quickly improved, with several firms jumping into the minilab manufacturing business. Between 1980 and 1986, the number of minilabs increased 1,740% in the U.S. market (Table 6.2). By 1986, minilabs accounted for about 20 to 25% of all photofinishing volume. Since the earliest minilabs were manufactured to process 35mm film, the format got a tremendous boost as a result.

Table 6.2: Increase in Minilabs

Estimated Number of Minilabs (in thousands)	
Year	Number
1981	0.8
1982	1.6
1983	2.7
1984	5.2
1985	10.2
1986	11.9
1987	14.7
1988	15.3
1989	16.1
1990	16.6
1991	17.2
1992	17.3
1993	17.5

Source: PMA Industry Trends Reports

Finally, the price-cutting witnessed during the 1980s played an important part in popularizing the 35mm format (*The Economist*, 1982). In 1982, an article in *Business Week* (1982) reported:

> Chaotic: There is no better description of the U.S. market for 35mm cameras. In an almost suicidal frenzy, the marketing subsidiaries of such Japanese camera makers as Nippon Kogaku (Nikon), Canon, Minolta, and Olympus Optical are slashing prices to levels of three years ago or below, squeezing margins to 5% or less. This year just breaking even will be the mark of success....Taking a profit licking to preserve

market share is a characteristic Japanese reaction to the combined problems of no-growth markets and keeping factories going....Bite the bullet. Fujio Mitarai, president of Canon USA, which holds nearly 40% of the 35mm market, says that drastic price-cutting campaigns are part of normal competition. "But the gray market hurts us much more," he stresses. Minolta, with 20% of the market, has axed this year's advertising budget by "substantially more" than $1 million to plow that money into lower prices for retailers who would otherwise be forced to buy gray-market cameras to compete.... The burgeoning gray market stems from three interdependent factors: A gross oversupply of cameras, especially in Europe; the strength of the dollar vs. foreign currencies; and the loss of trademark-registration protection when the camera makers relinquished their U.S. distribution partners to set up their own marketing arms. (*Business Week*, 1982).

Similarly, in 1983, Braham wrote in *Industry Week*:

From casual snapshooter to serious sharpshooter, automation has caught the eye of today's photographer. Not only do the latest cameras stress automatic exposure; some also have automatic focus, flash, winding and rewinding -- even automatic loading.... Result: it really is difficult not to take a decent picture. Another bit of good news: even with their increasing sophistication, cameras are becoming smaller and smaller, simple to tuck into a briefcase or pop into a pocket. Plus, they have been plunging in price, particularly in the popular 35mm category. Because of overproduction by the Japanese (who make virtually all of the 35mm models), the gray market, and weakness in the yen, actual selling prices have been slashed almost in half in the last four years. List prices are just about meaningless. (*Industry Week*, 1983).

CONCLUSION

Disc technology was different from the Polaroid case study because it was introduced deliberately by an incumbent, thus challenging the assumption of institutional theorists that disruptive change arises from outside the field, since entrenched members have no incentive to introduce a new technology, which is not sanctioned by the field. Thus, Kodak, by virtue of its dominance in camera sales (Table 6.3), did not have an incentive to introduce the entirely new disc technology. The fact that it did, either means that it did not understand the difficulties that institutionalizing a new technology poses, or trusted its monopolistic power in the industry enough to imagine that it could bulldoze any change through the industry, or was responding to a strategic threat.

Table 6.3: Kodak's Dominance of the Camera Market

Year	Kodak's Market Share in Cameras
1970	65
1971	70
1972	69
1973	74
1974	67
1975	63
1976	53

Source: Kadiyali 1998: 92.

While we have no evidence to suggest anything about whether Kodak did or did not appreciate the difficulties of institutionalizing a new technology, from the analysts' and Kodak's own statements before the launch of disc technology, it is easy to gauge that its level of confidence in disc's eventual success was very high. A review of the literature in that period also indicates a relationship between the imminent arrival of electronic photography and the plans to introduce disc (pictures on discs could be shown on TV through special equipment), in which case the impetus could be called external. However, one notion for which much support is available is Kodak's quest to perpetuate the systemic nature of the industry, and maintain complete control over it. Thus, the impetus was both external (future threat from electronic photography) and internal (Kodak's desire to maintain control).

The more important question, however, is why was the disc not able to become dominant? Ostensibly it had Kodak's enormous clout behind it and the literature on technology evolution has often attributed success to the sponsor's clout (Teece, 1988; McGrath, MacMillan, & Tushman, 1992). Moreover, colleagues have often pointed out to me that Kodak's enormous clout compared with the rest of the fragmented industry may make the case of technical change in the photographic industry a unique one. Kodak, it is argued, can bulldoze any reasonable technology through the industry and make it a universal standard. Such an argument is not without merit. Kodak's dominance in the industry is beyond doubt. As an illustration, consider the following (also look at Table 6.5): In 1904, Kodak controlled 90% of the amateur film trade; in 1915 its share was 88%; in 1932 it was 84%; through 1976, Kodak's monopoly in film was uncontested; from 1958 to 1976, Kodak's market share averaged 68% in the camera market, 86% in the film market, and 89% in the color photographic paper market (Kadiyali, 1998). Even now, Kodak controls about 75% of the photographic film market in the United States. Fuji is a distant second with about 15% market share. Because of its ubiquitous yellow photographic film boxes, Kodak is known as the "Big Yellow Father," in the industry. A recent survey by Total Research Corporation found that Kodak was number 1 in its overall brand quality survey, beating icons like Disney and Mercedes-Benz, proving that consumers believe strongly in Kodak quality.

Table 6.4: Kodak's Dominance of the Film Market

Year	Kodak's Market Share in Film (%)
1955	84
1956	84
1957	85
1958	86
1959	86
1960	86
1961	83
1962	82
1963	82
1964	82
1965	85
1966	88
1967	91
1968	90

1969	89
1970	87
1971	88
1972	87
1973	87
1974	87
1975	86
1976	86

Source: Kadiyali (1998: 92)

Over time, Kodak has erected several barriers between itself and competition. It has always had a policy of erecting a wall of patents around its technological innovations, which have offered protection from smaller players who might have had genuine cases. This policy is reflected in the following statement by George Eastman, "I believe that $25,000 would put our patents in England on a foundation that would be unassailable. We have got so many patents that if we get beaten on one, we could try another and it would take our competitors ten or fifteen years to break them all down." (Jenkins, 1975). Similarly, it has had a policy against licensing its firm technology. While Kodak has on occasion licensed out its technology for its cameras, after being a sole producer for a while, it never licensed out its film technology.

Over the last 100 years Kodak has developed a competence in film technology that is unrivaled. The R&D costs associated with entry into film manufacturing are enormous. Even chemical giants like DuPont have been unsuccessful in entering this highly specialized business. Indeed, in the 1960s, Dupont spent 15 million in R&D costs and 10 million on plant and equipment in its bid to enter this business before Kodak made existing technology obsolete with yet another innovation, leaving Dupont out in the cold. (Dupont was looking at another $4 million in advertising expenses if it did enter).

Moreover, Kodak's ability to cross-subsidize entry-deterrence battles across its various markets and squeeze rivals in any one market provides it with an enormous advantage. In its bid to expand the amateur photography market, Kodak was able to develop a formidable mass-distribution system, which has been strengthened over the decades. To get film to consumers, a challenger would have to match this distribution network. In addition, after delivering film to the customer, the challenger would also need several photofinishing labs across the country to be able to promptly return processed film to consumers. Here also, Kodak's CPP has a wide network. To be able to process film quickly, the entrant would either have to go with independent processors, who would be willing (at affordable costs) to process film only if it were compatible with Kodak's photofinishing process, or the entrant could devise a new type of film and a new combination of chemicals to develop the film. However, it would be difficult to persuade independent processors to adopt new developing procedures for an entrant without a guarantee of a minimum volume of business in the new line of film. Therefore, the entrant's best alternative would be to devise a new type of film that could be developed using Kodak's processes, or be "Kodak-compatible." How an entrant can make Kodak-compatible film without violating Kodak's patents is a conundrum. Finally, Kodak's high advertising budgets combined with its economies of scale and scope make it extremely difficult for anyone to challenge it[49].

All these factors combine to give Kodak enormous clout in this industry and Kodak has periodically capitalized on it to introduce new technologies such as the 110mm and the 126mm camera-film systems. These technologies were not necessarily superior to what existed out there but represented different and proprietary standards. The introduction of the Instamatic camera and film in 1963 made it possible for amateurs to easily change rolls of film. This resulted in an explosion of sales, and profits for Kodak. More importantly, it defined a new format for photography, one that no competitor was in a position to imitate (b/c of patents) or benefit from. However, the fact that Kodak was not always able to replace an existing technology only goes to show that dynamics other than individual organizational clout are responsible for the success or failure of technologies. The case of the Disk Camera illustrates how even virtually monopolistic clout may not be enough to ensure technological success in the marketplace.

Kodak's failure to make the disc dominant can be attributed to two major factors: its inability or unwillingness to enroll support necessary to deliver on the claim that the disc technology represented, and the existence of an alternative, open network (35mm) for stakeholders, which represented a much less disruptive technology and the possibility of becoming the embodiment of their interests.

[49] There is persuasive evidence that product differentiation was a successful entry barrier.

Enrolment: The systemic control that Kodak had established over photography allowed it to monopolize the film market, which, as discussed in the Polaroid case, had assumed a critical position in the photography field. Film was the gateway to any photographic activity. It had been inserted between users and their objectives (rather like the Microsoft Windows Operating System today). However, in theory at least, there was nothing that could protect Kodak's domination in this product. If, somehow, another player or group of players, were able to get a head start on a different format (making both cameras and films) and generated acceptance for the new format in the market, Kodak's dominance would be threatened. It was thus to perpetuate its systemic control and hence its dominance that the completely new disc technology was introduced. As opposed to 35mm technology, however, the disc was a completely new technology. The camera, disc, film development and servicing all required learning for customers as well as vendors. Once, the learning was complete, the handling was easy. However, the transition required building new routines and re-organizing businesses. Was there a need to do it? As discussed above, Kodak tried to manage this process by creating tremendous market pull. And it was successful too. Due to the powerful Kodak brand, the camera sold in unprecedented volumes in its first year. Almost 30% of the cameras sold in that year were disc (Figure 6.4).

Figure 6.4 About Here

However, Kodak's brand was not enough to sustain this level of interest in disc technology. Due to the unwillingness of photofinishers, the disc was unable to deliver on all the claims that had been made regarding technology, wide/ immediate availability of related services and so on.

Competition from 35mm: Apart from the attraction of an open architecture, which could be modified to suit existing capabilities and manufacturing practices, in many respects, 35mm represented a filtered technology, the residue of several generations of photographic technology, making it substantially less disruptive than disc cameras. The design of 35mm cameras was essentially an assembly of well-established technologies and products. For instance, most models used common lithium batteries which consumers could use in several other applications as well. This was in sharp contrast with the unique wafer thin batteries that the Polaroid SX models used. Similarly, the format itself, 35mm, was well established as an familiar one that had been around for several years. Consumers knew exactly what the 35mm film was, and what they were supposed to do with it. The films were compatible across an extremely wide and expanding range of cameras and customers of 35mm film had a choice of cameras. Again this was in sharp contrast to Kodak's disc films that could only be used in Kodak's disc cameras (although new competitors were beginning to come on board with their own disc cameras). The 35 mm format extended not only horizontally, but also vertically. In other words, consumers starting with less expensive lens-shutter cameras could graduate to SLR models without having to change film formats or learn about the more sophisticated cameras anew. The fact that such a large range of cameras, both horizontally (same price category), and vertically (different price categories) used the same film served to increase photofinishing volume per minilab and decrease fixed costs.

On the other hand Kodak's discs were not only unique to their cameras, but completely foreign to consumers, dealers, photofinishers and other camera and film manufacturers. Indeed, it could well be argued, that rather like Polaroid's futuristic SX-70 model, disc technology was *too innovative*. It deviated from almost all established technological standards, making it immensely difficult for stakeholders to embody their interests in the new technology. Photofinishers, for instance, typically had a hard time processing and printing disc photographs to the extent that they bad-mouthed discs. On top of that, Kodak's quest to remain in complete control of this new format made the technology exclusionary, in stark contrast to the inclusive 35mm format.

On the other hand, 35mm's openness led to major bandwagon effects, something the disc could not generate. This fact in itself presents a dilemma. Path dependency theorists maintain that initial acceptance of a technology has a disproportionate influence on eventual success. In the four and a half years following its introduction, 25 million disc cameras had been sold, but no bandwagon effect took place. In 1983, disc cameras accounted for almost 30% of total camera sales which was about 5% more than 35mm cameras, which included expensive SLRs, a completely different category. This has two implications. First, contrary to path dependency arguments, it is not the number of *customers* which is critical to generating bandwagon effects, but the number of *stakeholders*. Adoption of a technology by stakeholders has a multiplicative effect on technology adoption, leading to increasing returns. Table 6.5, for instance, shows that by 1986 several people who had previously bought Instamatics or disc cameras, were buying 35mm cameras, thus indicating strong bandwagon effects in 35mm technology (Recall Figure 6.2 which illustrated that initial disc sales were mainly at the cost of Instamatics). Secondly, a number of customers buying a product or technology does not lead to increasing returns, since the technology cannot function without the existence of an entire network. Moreover, a quest for complete control also restricts the generation of bandwagon effects.

Table 6.5: Type of Camera Previously Owned

(By 35mm automatic camera purchasers in 1986)

Cartridge/disc	35.4%
SLR	25.8%
Lens-shutter	15.5%
No camera	15%
Instant	7.4%
Other	0.9%

Source: Photo Markeing Newsline: Photopinion, April 1986

Indeed, bandwagon effects that developed around 35mm format led not only to innovations in film (leading in turn to high quality images), but to several other developments, making 35mm a superior alternative to disc. Could it be said that the disc camera was doomed from the beginning? Not because of any inherent technological inferiority, but because it was competing against a similar technology based on an open standard? This is a question worth exploring in future research, and holds important implications for technology strategy literature.

FIGURES TO CHAPTER 6

Figure 6.1: The Share of 35mm Before Disc Cameras

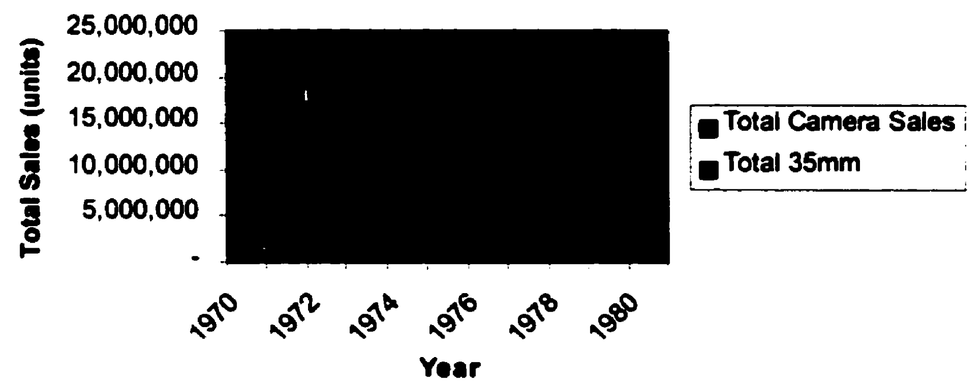


Figure 6.2: 35mm, Disc and Instamatic Sales 1974-1993

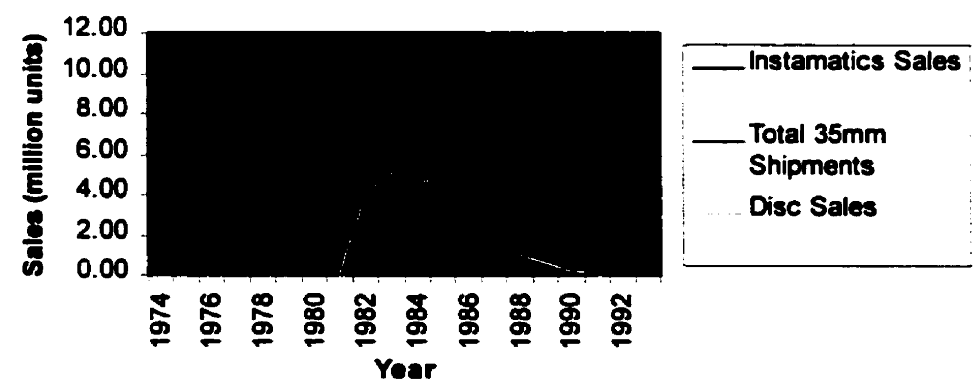


Figure 6.3: Disc Camera Sales

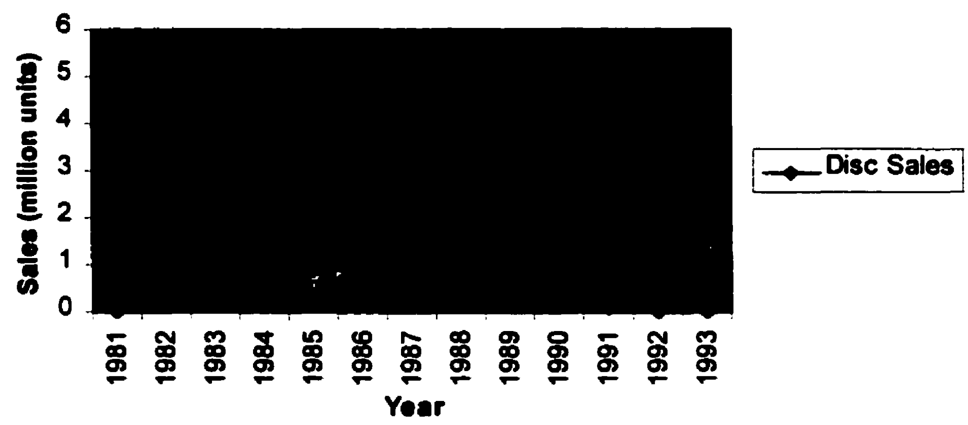
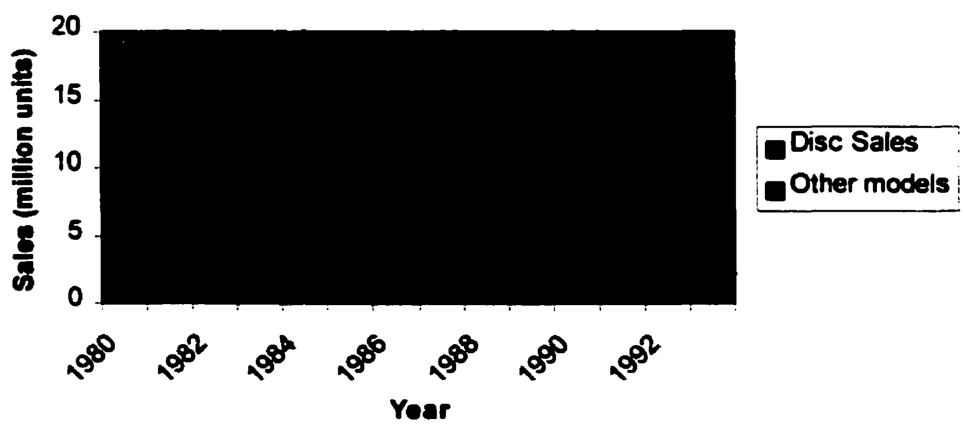


Figure 6.4: Market Penetration of Disc Cameras



CHAPTER 7: THE DIGITAL IMAGING REVOLUTION

The case of digital imaging technology is important in two major respects. First, while all three previous discontinuities represented the introduction of radically new proprietary technologies, digital imaging is a combination of mostly non-proprietary technology. In the previous cases we only witnessed a struggle for technological substitution, while in this case a larger dynamic exists where digital imaging technology is not only threatening/promising to substitute the incumbent technology (35mm) but within digital technology itself, several technologies are competing to become integral parts of the eventually dominant design of a digital camera. Secondly, it represents an open-ended case in that the success or failure of digital imaging has not yet been determined.

The case depicts substitution dynamics similar to what we observed in the three previous case studies. A discursive struggle ensued the introduction of digital imaging. This process was driven by the economic interests and existing capabilities of players who took part in 'constructing' the new dominant technology, both physically by introducing new technologies to perpetuate old ones and in terms of its social meaning. In other words, emphasizing the importance of image sharing or electronic storage. Large-scale changes in the institutional context such as the proliferation of PCs and connectivity through the Internet played an important role in transforming the issues around which the substitution struggle was being waged. However, how the institutional context influenced the shaping of technological evolution was determined by strategies pursued by firms. They engineered associations between the new technologies and emerging and/or existing institutions, thereby transforming the understanding of the nascent technology.

Substitution, or the selection of a new dominant technology (35mm, Photo CD or digital) was only one dynamic in this process. Design competition within digital technology, or the evolution of a dominant design for digital cameras, was the other. Contrary to the prevailing understanding in technology management literature, however, these two dynamics were not sequential or separate, but represented a co-evolutionary, recursive relationship. Substitution-related issues such as what the tradeoff between quality of image and connectivity should be drove design battles within digital: which sensor to use? Should a PC be part of the consumption chain? While the latter -the use of a floppy by Sony influenced the success with which digital was able to substitute for traditional say by increasing the simplicity of the design.

While there is no conclusive evidence of digital imaging's success or failure, it is evident that in the past twenty years, several new practices, rules, technologies and networks have evolved around the issues, which followed the introduction of digital imaging. All this has led to a changing understanding of photography, positioning some technologies in stronger positions than before. In this chapter, I describe the role that firm-level strategies and larger changes in the institutional context have played in this process.

This chapter consists of two parts. In the first part, I describe the case of digital imaging in terms of technological and strategic developments. In the second, I discuss why technology has followed a particular evolutionary path, the role of firm strategies and institutional changes play, and present some tentative conclusions drawn from this case.

THE EXCRUCIATINGLY SLOW PROGRESS OF DIGITAL IMAGING

It is clear that the progress of digital photography has been excruciatingly slow. Sony introduced the first entirely electronic camera in 1981, and by 1998 this category of cameras controlled less than 4% of the market share in the U.S. camera market. In this section, I attempt to give a brief description of the developments along this trajectory, which should lead to an enhanced understanding of why the progress of digital has been so slow.

Introduction

While advanced electronics had been seeping into traditional camera design for several years, it was not until 1981 that the world was introduced to an entirely electronic camera called the MAVICA (Magnetic Video Camera) by Sony. In place of a film, the MAVICA camera had a sensor called a charge-coupled device (CCD), which captured the image in digital form. The image was stored on 2" floppies (a unique storage medium), and Sony itself admitted to its poor quality which was reminiscent of photocopies of 35mm color prints). The camera could then be linked to a TV, color printer or even a computer. Since color printers were very uncommon in those days, Sony introduced a special Mavigraph printer in tandem to print electronically captured images.

Sony was followed by Canon, which brought the first all-electronic camera to the market in 1986. Soon other electronic companies such as Hewlett-Packard, Toshiba, Sharp and Hitachi were seen committing resources to developing electronic imaging. Through the 1980s, these firms were not considered part of the 'photographic industry' although the threat that they posed was increasingly being felt by. Electronics players were vying to bypass the distribution and retailing channels that had been established over a hundred years and sell cameras through electronics stores, thus changing the perception of photographic activity.

The Threat to Incumbents

Digital imaging represents a serious, two-pronged threat to incumbents in the photographic industry. First, committing to digital imaging completely means giving up competences that have been developed in chemical-based imaging over several decades, not to mention existing market positions and competitive advantages. Firms like Kodak and Fuji derive a large part of their income from selling film, while thousands of photofinishers and several chemical suppliers are entirely dependent upon the existence of film. If everyone starts using a film less camera, Kodak would be just another firm on the street and all photofinishers would be driven out of the market. Similarly, it could mean the end for conventional photochemicals and the robust profits they provided (Chemical Week, 1982). Secondly, while there is the lure of being first-movers in this arena, the barriers to entry are considerably lower than they were in chemical-based imaging. Whereas film manufacturing is a highly specialized task requiring hard-to-imitate implicit knowledge, electronic cameras constitute easily available, codifiable knowledge and parts. Soon after Sony displayed the MAVICA, Ty Govatos, photography industry analyst at Bache Halsey Stuart Shields Inc., argued,

> Almost anyone can make the magnetic tape or discs used to record video signals.... So you'll be substituting a product that has pretax margins similar to those earned by a flour mill, versus [conventional color film] made by a sophisticated chemical process, which generates operating margins of 50% to 60%. (*Business Week*, 1982: 38)

However, given the extremely high cost and generally not-needed features that electronic cameras boasted, the threat was not immediate. Also, from the perspective of many in the field, electronic imaging was a technology which would be relegated to a niche, most probably that of press photographers[50]. It was considered irrelevant to existing consumer needs. Proponents of electronic imaging reinforced this view. Canon USA President Fujio Mitarai admitted in 1986 (Forbes, 1986) that his target markets initially were newspapers and broadcasters. But as soon as the camera could be reliably mass-produced, the market should broaden considerably.

For ordinary users, apart from poor quality images, electronic photography was hindered by the unavailability of hard copies, the necessity for a T.V. and later PCs as a viewing device, short-battery life, the incompatibility of file formats, memory devices and at times the requirement of connecting cables to download images. All this made

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[50] This view carried well into the late 1990s. For instance, John Seinkowicz, a Vice President at Minolta, echoed the sentiments of many other camera manufacturers by remarking:

"Right now digital cameras are simply computer accessories, nothing more than that. Actually they have followed a market trajectory very close to that of camcorders. There was all this hype that camcorders were going to wipe out still cameras. There was voice, motion, cheap films, universal presence of VCRs, one standard...everything was perfect. But did that happen? No. Camcorders could not give the same experience to consumers. They had to make an entire movie and then watch it for the same length of time. Who wants to do that? Camcorders have secured a niche to record weddings and other functions along with still cameras, but where picnics and other regular events are concerned, still cameras are still the most popular medium....Most probably, though, there will be a fragmentation of the market, with some people using digital cameras and all others traditional cameras, just like the camcorders" (Author's interview with Sienkowicz, March 1999).

photography more difficult, argued Kodak's President Chandler. Chandler dismissed electronic cameras as unfeasible because people liked color prints and digital technology did not deliver a high quality set of prints as yet. To Chandler and many others in the photographic industry, it was inconceivable that people's 'need' to touch, feel, and pass around hard prints could change (Newswire, 1981). Moreover, Chandler argued that improving the resolution and speed of electronic imaging translated directly into the cost of an all-electronic camera. And reaching the standards set by chemical technology would result in prohibitively high prices.

A Summary of the Major Issues Facing Digital Imaging

The introduction of digital imaging meant that several aspects of silver-halide photography, that had gone unquestioned for several years, became subject to scrutiny again. At the same time, however, traditional photography was a natural benchmark against which the new technology was gauged. Based on the existing understanding of photography, digital was considered 'unfeasible' on several counts.

Quality of image was the single most frequently cited reason for the 'unfeasibility' of electronic photography that I encountered during interviews. The optimum resolution deliverable by such a CCD was around 280,000 pixels and fell far short of conventional film which boasted anywhere from 2 million to 10 million pixels. As such, Colby Chandler, Kodak's CEO, asserted that film remained the premier image-recording medium for consumers. Chandler questioned whether an all-electronic camera could ever satisfy the expectations of consumers.

> "An all-electronic camera with a million picture elements or fewer could most likely yield an acceptable print for certain types of scenes, especially close-ups or scenes with minimum detail in the highlights or shadows. But consumers expect and deserve picture-taking opportunities over a wide range of photographic space, and we continue to provide film and camera systems that meet their expectations and expand their opportunities at a reasonable cost. From that perspective, it becomes

apparent that it will remain difficult for electronic systems to approach the performance and cost of their photographic counterparts." (*Business Week*, March 1982: 38).

Other experts and analysts had similar reservations. For instance, in 1984, the *British Journal of Photography* wrote of the electronics revolution,

> "It is surprising that electronics is still seen as a threat to photography whereas in practice the more convenient, higher-quality silver-based photography has all the advantages. For example, it has been estimated that to provide the electronic equivalent of the detail which can be recorded on a 35mm motion picture frame – half the size of that used in 35mm still cameras – a TV system with over 2000 lines would be required. The best current standard is 625 lines and even the best high definition system proposed for the late 80s has still only some 1100 lines." *(British Journal of Photography, Annual Issue*: 1984: 7).

Another issue which arose with the advent of electronic imaging, was that of complexity. Apart from poor quality, electronic photography was also hindered by the necessity for a T.V., PC monitor, as a viewing device, as well as short-battery life, incompatibility of file formats, memory devices and at times the requirement of connecting cables to download images. Kodak's objective, stated President Chandler, was to make photography "decision-free" and electronic cameras "did not meet that requirement by miles" (*Newswire*, 1981).

Kodak's marketing experts insisted they had an edge over digital photography because of "consumers' long-term love affair with snapshots" (*Newswire*, 1981). Kodak CEO Chandler said that in the early 1970s, nearly one-third of the amateur pictures made in the U.S. were shot on slide films, but "[t]oday, fewer than 15 percent fall into that category" (*Newswire*, 1981). To Chandler and many others in the photographic industry, it was inconceivable that people's 'need' to touch, feel, and pass around hard prints could change. Indeed, people had preferred prints over slides and there was no reason for them to go back Kodak's attitudes towards hard prints were echoed through the industry. According to the *PMA Strategy Report* (1991), the industry needed to build on the assumption that people will always want hard prints and fortify their strategic plans accordingly.

New Features

While the aforementioned factors were important considerations when stakeholders evaluated the feasibility of digital cameras, there were also several new features that such cameras offered. Most of these features were not regarded crucial as yet, and many regarded them as irrelevant to the existing needs of the public. These included the ability to capture an infinite number of images without having to replace film or pay to develop it, to modify them and instantly share them over the Internet. With digital technology, the photographer was not restricted to 12, 24 or 36 exposures but could take an infinite number of photographs, subject to some constraints such as the capacity of the storage device or battery life. Similarly, another important issue that digital imaging raised was the possibility of sharing images with contacts all over the world. Finally, digitized images made it possible to modify images. Software could be developed for PCs, allowing users to modify photographs, thus snatching this specialized ability away from professional photographers. However, even if they used it, press photographers did not generally acknowledge using this feature, for obvious reasons.

Given the existing institutional context, these features did not necessarily appeal to consumers. For instance, the images could only be shared if PCs were widely available and affordable and the Internet universally accessible. Naturally, in the early days of digital cameras, this was not the case (PCs were introduced in 1981), and unless the penetration of PCs and Internet in U.S. households grew dramatically, this feature was not highly important. Similarly, whether the modifying of photographs was desired was not clear. Photography was cognitively associated with the so-called accurate representation of subjects, and consequently, suggestions of their modification were greeted with criticism from cultural critics. The following quote from the *British Journal* *of Photography* (1982) is especially reflective of this conflict between technology and values:

> "With all the emphasis on apparatus nowadays, with promotional pressure exerted on all sides it is vital to bear in mind what it is all about – the picture. Camera owners are in some peril today of becoming apparatus users rather than photographers.....The 'advantage' that electronic engineers hold out is that their systems will not need a darkroom. True, photographers will not regard this as an advantage at all but as a great disadvantage, since it is in the darkroom that a great deal of the creative work is done. True photographers are people who have sufficient individuality and incentive to go out and originate pictures, they are not like audio and video enthusiasts who just like to sit down and be entertained by the efforts of others. To them it is the fact that the photographic image recorded on film can be made into a negative or a positive by a variety of processes with a very wide scope of possibilities under the photographer's control, which is the attraction of photography" (*British Journal of Photography*, 1982: 21).

Changes in Institutional Context

Naturally, the 'value' of digital imaging technology partially depended upon the institutional context in which stakeholders made sense of digital imaging. Various norms and cognitive beliefs had evolved around photographic technology, which supported existing ideologies. In the early 1980s, photography was equated with 4x6 snapshots, taken mostly by autofocus cameras at social occasions. These occasions or 'Kodak moments' were institutionalized as the occasions where photography was 'normally' practiced, or where camera owners were expected to use their cameras. A look at film sales across any single year shows sales peaking around summer/ vacation and winter/Christmas (Table 7.1) thus illustrating the generally accepted use of cameras for specific occasions.

Table 7.1: Photography Breakdown by Season (1997)

(Percentage of picture-taking activity by Period)[51]

	Season			
Type of Camera	Jan-Mar	Apr-June	July-Aug	Oct-Dec
Disc	10.7	12.0	36.3	41.0
110	14.1	21.3	25.6	39.0
35mm automatic	14.2	21.4	26.9	37.5
APS	15.1	20.5	26.7	37.7
Camcorder	15.2	19.8	29.1	35.9

Source: *PMA Consumer Photographic Survey*, 1997.

The cognitive lens that people used to understand photography in the early 1980s likewise consisted of internalized 'truths' about it. That photography was carried out to preserve memories and photographs were to be stored in albums and displayed in frames were notions that were never questioned by the public. Industry members were convinced that consumers would never let go of 'hard prints.' Hard prints were equated with photographs, while 'images' were somehow considered ephemeral. Initially even the proponents of electronic 'imaging' strove to somehow convert images into photographs by introducing color printers, but the resolution and price differential was too great to effectively compete against a highly entrenched support system that had formed around traditional photography.

These norms and cognitive frameworks provided the institutional context through which people made sense of photography and related technologies. However, some major developments in the institutional landscape during the 1980s and 90s changed this context. Perhaps the most important change that affected how photography was understood was the information technology revolution. Almost every daily practice such as shopping, communication, work, retailing, and manufacturing underwent a dramatic change. At the same time, perhaps less noticeably, relationships and common institutionalized understandings of all these practices changed. For those with access to

[51] These figures are based on a large-scale household survey conducted by the Photo Marketing Association.

computers, how one communicated, shopped, organized and managed information or a business and even how one spent time at home or office, all changed.

In U.S. households, the penetration of computers had grown steadily since 1981, when PCs were introduced. By 1998, U.S. PC household penetration had reached 50%, according to InfoTrends' 11/98 *Digital Camera Penetration Survey Report*; 60% of those households accessed the Internet, and 18% had a scanner. At the same time, dramatic changes in telecommunications allowed consumers to communicate instantaneously and transfer large amounts of visual data over the Internet. As PCs increased their penetration in the 1980s, textual data was supplemented as well as supplanted by visual data with rapid speed. The 5 ¼ inch floppy disks emerged as a standard storage device and in various places computers were beginning to communicate with each other, with transfer of visual images gradually increasing in frequency. The rise of PCs and later on the Internet, were events unconnected to the technological developments in the photographic industry, but had enormous influence on technological evolution in the latter industry. The universal presence of advertisements, billboards and soaring TV viewer ship brought practically the whole world face to face with new products and technologies. Highways became littered with billboards flaunting the "liberating" ideology of the Internet. The message was clear: consumers are freer and more powerful than ever.

With the bombardment of computer and Internet-related advertising, and the proliferation of computers in offices and everyday work, the level of computer literacy of the average American also increased dramatically during this period. Monitors, CPUs, floppy disks, CDs and printers were no longer novelties but grew into technological institutions. As applications proliferated, convergence in various computer-related technologies resulted in various dominant designs at different levels; Microsoft Windows as the operating system, Microsoft Word as the dominant word processing package and 3.5 inch floppies as the universal external storage medium.

Technology Substitution: Strategic Responses to Digital Imaging

In a changed institutional landscape, digital imaging represented a renewed challenge for incumbents. With PCs and access to Internet becoming increasingly affordable and universally available, sharing of textual and visual data was an everyday activity. Normative pressures were encouraged people to share images with friends all over the world and to use digitized images for a variety of new purposes, both professional and personal. Although by the early nineties such activities were limited to a few, it was becoming increasingly clear that with software getting more user-friendly and universally compatible, this trend would only grow while trickling down to all computer users. Kodak quickly introduced its own solution, which promised to perpetuate traditional photography and yet allow people to share images over the Internet or modify them. The solution was Photo CD.

Photo CD

The idea behind Photo CD was that consumers could send rolls of exposed film, taken with traditional 35mm cameras, to qualified photo finishers and in return receive both hard-copy prints and a Photo CD disk, the cost of which was approximately $20.00. Photo CD disk provided an alternative storage medium that held digitized images of the prints, which made making modifications on the computer possible. The CD was not a common storage medium for information at the time, which meant consumers were forced to buy the Photo CD player (costing about $400.00), which displayed digital images on a TV screen or computer monitor. The CD provided easy storage, organization, image manipulation, and retrieval. Thus, the Photo CD system enhanced and preserved the value of photographic film to Kodak customers and represented Kodak's first line of defense against the evolving potential of affordable digital imaging as a substitute for chemical film and processing. While the cost for a Photo CD was undoubtedly a deterrent for initial consumer enthusiam/response, Kodak argued that someday prices were bound to be lower. Another issue not as easily solved by price was the use of the TV set. At the time, TV was the main component of the home entertainment center. There was no way to tell if a consumer would purchase additional hardware and absorb extra processing costs to view still pictures on the TV screen. Photo CD meant that consumers paid $400.00 for the least expensive player and then pay at least $20.00 to get their images on a CD.

In addition to the disk and player, the Photo CD system comprised a photo finishing sub-system for commercial film developers. This sub-system had a scanner, workstation with photo finishing software, and a CD recorder. Kodak was pricing this workstation at around $100,000 and rather optimistically forecast its productivity of 300 images per hour from 35mm color-negative film. Photofinishers, especially small independent ones, were reluctant to adopt the new system at such a cost.

In a straightforward manner, Kodak equated the success of the Photo CD with the perpetuation of the existing photographic technology, and looked to enroll dealers and photofinishers in its network. This view supported the notion in the field that digital imaging might actually cause growth in film sales. After all, in the early 1980s, experts had prophesied computers would replace paper. However, the use of both paper for the print output and words had multiplied. The PMA *Industry Trends Report* argued that:

> [C]omputers now have moved from word processing to image processing. Many who never before used photos in their professional or personal lives will do so. Digital systems empower commercial clients and consumers to produce the photos they want. They provide more ways in which to use photos. From a marketing perspective, if there are more users, more uses, and more satisfaction with a product, then sales should climb. (PMA 1991/92 *Industry Trends Report*).

Digitization of images reinforced this view, providing yet another basis to expect growth rather than a decline in the purchase and necessity of roll-films. However, irrespective of whether Photo CD boosted the sale of film or not, its own sales were much below expectations. By the late 1990s, it was clear that Photo CD was not a viable option for consumers. Kodak's new CEO, George Fisher conceded that Photo CD was not a consumer product, and had essentially failed. It was, however, repositioned as a tool for professional users. Simultaneously, Kodak launched a consumer version in collaboration with Intel, called Picture CD. The idea was basically the same. The consumer took an exposed roll of 35mm film to a photofinisher. The film was developed by the standard chemical process, then the slides or negatives digitized using a high-speed Kodak film scanner. A Sun SPARC station corrected image density and color and a Kodak writer recorded the images on a Picture CD disc. An index print of the images was created by a Kodak XL7700 printer, a continuous-tone printer that produced near-photographic quality prints from digital sources. The consumer walked away with the negatives, index prints and Picture CD disc in a jewel case, all for about $16.00.

The Picture CD provides an alternate evolutionary path for technology which makes cameras are redundant. Like digital cameras, it embodies the interests of several stakeholders, foremost among whom are Intel which lends its digital technology expertise, Adobe whose software is included in the disc to allow modifiability, and CD drive manufacturers, photofinishers, film and camera manufacturers and chemical suppliers. However, the success of Picture CD is still beyond the control of these players. If it is to be successful, people must have a CD drive in their computer and thus computer manufacturers need to be enrolled too. With the increasing trend towards miniaturization and lighter, portable computers, CD drives have become a peripheral device. The emerging field will likely go through several other changes before Picture CD becomes as ubiquitous as roll film, if at all.

Advanced Photo System

In an attempt to rejuvenate sales of traditional film, five of the largest firms in the photographic industry joined in 1996 to launch a completely new format in traditional photography: the Advanced Photo System (APS). APS film is smaller than 35mm. At 24mm it allows the construction of cameras at about 20% reduction in size, and because of advances in emulsion engineering, the image quality does not suffer noticeably. The new system adds a magnetic layer coating to the film that is used to record specific camera data to help the photofinisher make better pictures. The user can take images in three different sizes and the film is designed for foolproof loading; it basically drops in like a battery cell. Finally, it is not possible to open the camera if the film is not fully rewound inside the cassette thereby making it impossible to open the camera camera by mistake. APS film is slightly more expensive than 35mm and its processing costs more. As yet, several photofinishers still do not have the equipment to process APS films, although the number is increasing. APS is incompatible with 35mm format (cameras or finishing equipment) but its proponents claim it to be the photographic system of choice in the future, because of its several advantages. APS was widely expected to take photographic activity to unprecedented heights. However, by 1998, APS cameras only occupied about 18% share of the total amateur camera market (Table 7.2). As Table 3 shows, this market share was primarily achieved at the expense of 35mm lens/shutter cameras. At the same time, digital camera sales were growing by around 100% every year since their introduction in 1988 (Table 7.3).

Table 7.2: Market Share of APS Cameras

Year	Total Camera Sales	35mm (l/s)	APS	APS Mkt Share
1981	16,500,000	800,000		
1982	17,500,000	1,300,000		
1983	17,800,000	2,300,000		
1984	17,000,000	2,900,000		
1985	17,800,000	3,900,000		
1986	16,400,000	5,000,000		
1987	18,700,000	6,400,000		
1988	17,800,000	7,500,000		
1989	17,200,000	8,600,000		
1990	15,600,000	9,000,000		
1991	15,500,000	9,500,000		
1992	15,400,000	9,900,000		
1993	15,800,000	10,100,000		
1994	15,500,000	9,900,000		
1995	15,000,000	10,000,000		
1996	15,100,000	9,800,000	1,100,000	7.28%
1997	15,600,000	9,000,000	2,300,000	14.74%
1998	16,200,000	9,100,000	3,000,000	18.52%

Sources: PMA Industry Trends Reports 1998/99

Table 7.3: The Ascent of Digital Cameras

Year	Total Digital Camera Sales
1988	30,000
1996	350,000
1997	740,000
1998	1,100,000

Sources: PMA Industry Trends Report, 1988/89; *Digital Imaging Association Consumer Survey, 1999*

Design Competition: Emergence of New Standards

At this stage, there were two paths down which this technology could evolve. . One was into Picture CD whereby users would use 35mm or APS cameras to capture images and then receive them on CDs. The other option was a purely digital direction. The battle here was being fought between communities that had formed around the traditional and digital concepts of photography. However, at the same time, another battle was being fought within the digital imaging arena for the dominant design within digital in terms of what kind of storage medium, sensor, shape or other features were to be adopted. [52] While functionality was generally perceived to be the driving criteria. After all, parameters for storage media, sensors, file formats, were straightforward, and could be compared objectively the success of Sony's MAVICA cast doubt upon this perception.

Sony and the Selection of a Storage Medium

In 1998, competing designs in digital cameras utilized completely different, often incompatible components. For example, Sony employed 1.44 MB floppy disks as storage devices while Kodak employed CompactFlash and Smart Media cards, which could store vastly more amounts of visual data than floppies. However, Sony's Mavica quickly captured 40% of the market in digital cameras The industryat first was at a loss, but then quickly latched on to the "simplicity"explanation. Jeff Vanscoyk (Vice President at Minolta) emphasized the anomaly as follows:

> Sony currently has 40% share in a 1.2 million unit market. When they started using the floppies, they became the butt of many jokes, since the quality was pathetic, and the camera was overpriced by at least $300. We were all dumbfounded by the success of the Mavicas. The Mavica is still the lowest performing camera but still doing the best. (Interview with author, March, 1999).

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[52] As mentioned earlier, these two battles were not separate or in sequential order. Rather, the developments within each influenced one another profoundly.

The Mavica uses floppy disks for storage which can only store about 9-10 images as compared to several times more that can be stored in SmartMedia or Compact Flash type memory devices. The latter technologies are widely understood to be far superior than floppy disks but did not gain the popularity that the floppies attained. Indeed, the popularity of floppies amazed even managers at Sony. When I asked Andrew Mougis, Executive Vice President at Sony, U.S.A, he remarked:

> The market never ceases to surprise us. Regarding the surprise of other manufacturers about Mavica, it is always amazing how the public will react to various products. It is always our hope that they will take off like the Mavica has. Clearly in this case, the 3.5 inch floppy, and the resulting simplicity of the system made all the difference in the world." (Personal correspondence, March, 1999).

The customer does not want to learn anything new, industry executives argued. They knew the floppy and they went with it. Despite the fact that Mavica was more expensive, stored fewer images and produced poor resolutions than competing models, it clearly ranked higher on whatever evaluation criteria the consumers were employing. However, if simplicity was the reason, why didn't the other manufacturers rush to incorporate floppies in their products? Jeff Vanscoyk has this to say when I asked why Minolta doesn't start using floppies now:

> "well, a me-too product at this stage is probably not a good idea. And I think that Sony's technology is soon going to be dead because of low performance. Also, for megapixel designs compactflash memory is now available in 128MB, while Smartmedia is only available in 32MB. And the floppy is a pathetic 1.44MB." (Interview with author, March, 1999).

A Battle for Supremacy: Compactflash vs. Memory-stick

In their more recent, post-1998 models, however, Sony replaced the successful floppy disk with a completely new and unique medium: the memory-stick. The memory-stick used the form factor of a stick of chewing gum and was available in 4 and 8MB. A 4-Mbyte stick could store 15 frames of UXGA images. A 16-Mbyte stick could store 65 frames of UXGA images or 260 VGA images. When used for MPEG-1 movies, the stick could store 10 minutes and 40 seconds with 160 x 112-dot resolution, or 2 minutes and 40 seconds with QVGA resolution, according to Sony.

The decision elicited skepticism from the industry on two grounds. First, Compact flash was emerging as the clear leader and had already been adopted by a wide range of players, so Sony's decision to come out with a proprietary design of its own, which no other digital camera manufacturer adopted, seemed foolish. Secondly, functionally, the memory-stick stored far fewer images than Flash memory or even Smart Media cards. Moreover, considerable positive externalities had already developed around Flash memory and none around Sony's memory-stick. Analysts such as Mike McNamara of Popular Photography were unconvinced,

> For memory-sticks I don't see much of a future since Sony is going it alone. Nobody else supports that format. However, that is probably because Sony has had a lot of successes all by itself, which gives it the requisite confidence. Like floppies for instance. However, the resolution is just not there in their cameras, and it can't last for long. Sony hit the market in the middle, average price with average performance, with underlying simplicity. (Interview with author, March, 1999).

However, Sony did not seem to be 'going it alone.' As Andrew Mougis of Sony pointed out:

> Unless Sony drives this technology, no one will. It takes action to create a reaction. We look for other manufacturers to join us in defining the future of consumer digital photography. Certainly the idea is to embed

> the technology seamlessly into everyday products so we do not think of each product as a special computer product, just products that allow us to enjoy the experiences of images, sound, and even data, without complexity or high cost (Interview with author, March, 1999).

Shortly after Sony announced licensing agreements with several manufacturers around the proprietary memory-stick technology. In 1999, for instance, it was announced that six companies had acquired licenses for Sony's Memory-stick technology. These included Aiwa, Kenwood, Pioneer, Sanyo Electric and Sharp (*Electronic Engineering Times*. October 18, 1999; 44). None of these firms, however, were part of the 'imaging' field. In a clever strategic move, Sony had introduced new externalities, based on its own competence and strength. Instead of choosing a technological format shared by most imaging firms, Sony strove to make the memory-stick compatible across all electronic devices. Indeed, in 1999, Sony announced a new Memory-stick Walkman (Electronic Engineering Times. September 27, 1999; Publication Year: 1999). Soon thereafter, Sony released an entire line of digital imaging products based on Memory-stick including the Digital Photo Frame, Digital Handycam camcorder, Cyber-Shot digital camera, and VAIO Slimtop LCD computer (*PTN*, 1999). Soon after, Sony announced memorysticks would be universally acceptable across cellphones, computers and all other electronic devices.

Sensors and File Format

Just as various technologies were competing to become the dominant memory storage component in digital cameras, the competition for sensor and file format was also ongoing. A sensor is simply a device located at the focal plane just behind the lens in digital cameras. During exposure, it records the image, then writes that data into memory before the next picture is taken. Charge Couple Device or CCD type sensors are currently used in the majority of cameras. However, it is not the only alternative. Another chip recently arrived on the scene: an image sensor called CMOS (Complimentary Metal

Oxide Semiconductor).[53] In the same price range as CCDs, and a higher resolution but CMOSs do not yet rival the performance of high-end CCDs. However, they do offer important advantages in system complexity and systems price; in many cases the use of CMOS enables applications or performance levels that were previously not possible. The eventual selection of a sensor depends upon several factors. These include the price which is dependent on several aspects of the design: its ability to lend itself to achieving economies of scale and sales; the sensor's ability to perform in sync with other components; and the number of stakeholders behind it.

File compression offers a similar case. The file compression mode interacts with the sensor to determine how sharp the final image is. When a digital camera grabs an image, it usually compresses it, reducing the file's size. There are several methods of compression, but the most common is known as JPEG. Remember that a digital camera takes the light waves coming through the lens and, rather than those light waves interacting with a chemical coating (film emulsion), the CCD and related circuits convert the light waves into an electronic signal made up of 1s and 0s – binary notation. It takes a large quantity of ones and zeros to describe an image. The compression system follows set mathematical rules to eliminate as much duplication of information as possible. For example, in a picture with of which the majority is blue sky, the formula will give a full binary description of the sky for the top left corner, then transmit the electronic equivalent of "ditto" for the rest. This can significantly reduce a file's size. For more complicated portions of the image, other compression schemes are used such as rounding off. Although this affects the image quality, this compression typically creates file sizes that "max out" at less than 50K. Some cameras have a feature that allows you to opt for greater compression at a noticeably further reduced level of picture quality for files of approximately 25K or so. While this delivers more pictures in the same amount of storage area, pictures are of lower quality. Typically a digital camera will offer resolution somewhere in the neighborhood of 640*480 pixels, halving these numbers for lower resolutions. CMOS chips will deliver higher pixel counts, as will more expensive CCDs. But it is the file size that counts. If the file size is less than 50K, the displayed image is

[53] In fact, CMOS arrived earlier than CCD, but for a variety of reasons, the latter was widely adopted to the expense of CMOS.

portrayed in standard resolution . It is the compression that affects this resolution adversely. While a number of file formats were competing only a few years ago, the list has been shortened to TIFF, JPEG and Flash Pix.

THE EVOLUTION OF PHOTOGRAPHY (1981-1998)

In the last 18 or so years, photography has transformed into 'imaging.' the difference is not merely semantic as illustrated by Johanne Mussche, President of PMA, CEO of Belgium's largest photofinishing chain, and a staunch supporter of silver-halide technology:

> I believe the wording we use is important for the position we take in the consumers' mind. HP came to the market with their Photosmart product line. They called it Photo not Image Smart. They wanted to come into our market and to position their product clearly as a photographic solution.... I believe we have to use the term photography for all the activities in the emotional half of the industry. So I believe brand names like Image Plaza and Image Magic create confusion in the mind of the consumer. The last thing to do is to become Image Marketing Association (instead of Photo Marketing Association)..... Digital photography and silver halide, or conventional photography, are both specialties that belong to our area of competence. By using the term "imaging" for this kind of photography, we create an unfocussed image of our business. Coca-Cola or Microsoft Windows are not more technologically advanced, nor better or cheaper products, but they have superior marketing....In our case, good marketing will remind the customer of the emotional value of our products and services. This value should be a key element in our marketing decisions"(*Photo Marketing Magazine*, February 1999: 7).

Stakeholders in the traditional photographic technology have a clear vested interest in perpetuating film-based photography, and preventing it from becoming 'imaging.' While many might argue that this community is fighting a losing battle, it cannot be denied that their efforts have been at least partially responsible for restricting the market share of digital cameras to less than 5% in the last 20 or so years. Moreover, the fact that only 50% of U.S. households and significantly fewer in the rest of the world have PCs gives them a great deal of confidence regarding the prospects of digital imaging's possible dominance. Those who do own computers have the option of receiving digitized images on Picture CDs. The incumbents also have several resources at their disposal including a monopolistic control of distribution channels, brand names and long-standing reputations in photography, apart from advertising dollars.

Constructing Photography: Tactics of the Film Group

Photographic technology has always been understood in terms of the equipment's ability to capture the image as accurately as possible. It is no surprise then that almost all incumbents believe that quality is also the primary concern of users. Jeff Vanscoyk, Vice President of digital products at Minolta argued: "Pictures should not only be viewed as a functional artifact. Memories are more important than the dishes in your cabinet. The images should be as good as possible. These are the things people grab first when their house catches fire." [54] Kodak emphasized the higher quality of chemical-based imaging, citing numerous market research studies showing that photographs are the customer's dearest possession, and hence need to be of the best quality possible.[55] Thus, through their advertisements film manufacturers are seen stressing the quality of images produced by their films. They also emphasize the fact that digital cameras cannot produce images of that quality, and when enlarged, digital images disintegrate into pixels, choosing to overlook that only about 5% people ever ask for enlargements.

While the gap between silver-halide and digital images was still quite wide, digital cameras offered the benefit of digitized images, easily shared and reproduced over the Internet. Kodak's strategic introduction of Photo CD was an attempt to meet the

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[54] Author's interview with Vanscoyk (1999).

connectivity and modifiability issue head on. Photo CD, and later the Picture CD, re-drew battle lines. Kodak was now supportive of the use of PCs; its advertising campaigns encouraged digitization and transfer of images over the Internet. Kodak hoped that Picture CD would boost sales of roll-film cameras, as the following quote from James Meyer, Senior Vice President and Chief Technical Officer at Kodak reflects:

> "[T]hese new capabilities -- along with e-mail and Internet applications -- will eventually drive picture usage levels two or three times current levels. The barriers separating silver halide and silicon are dramatically lower than even a few years ago. This gateway is only going to get more convenient.....Traditional silver halide technology will have a dominant place in this expanded world of pictures. People in a digital world will still want hardcopy and films that are human readable, whether in consumer or commercial applications. A picture in the hand may be worth at least two or more on the hard drive" (*Business Wire*, 1998).

Similarly, E. Fitzgerald, General Manager, worldwide consumer imaging services Eastman Kodak stated:

> The best opportunity for profit lies in combining digital imaging – distinctly different from digital cameras – with traditional film services. The industry as a whole has kept secret from the consumer what digital imaging can do. For $15, consumers can have a roll of film processed, and the negatives scanned and written to a floppy disk. There isn't much money to be made just selling digital cameras, but there is a lot of money to be made with digital imaging" (*Business Wire*, 1998).

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[55] It is ironic that nearly a hundred years ago, Kodak attained dominance by emphasizing convenience and portability of its roll-film cameras over the much better quality offered by dry-plate camera.

The combination of silver-halide and digital thus became Kodak's rallying cry; around which it mobilized its network. Moreover, new actors were added to the institutional field as Kodak developed an alliance with Internet service provider, America Online to start a program called "You've got pictures." This program would have a consumers' images emailed to him/her from participating photofinishers, along with a set of hard prints. Thus, through the involvement of other technological institutions in a consumer's life, namely, a TV set, a PC, and the Internet (AOL), the community supporting the traditional film business had been expanded. Major actors, such as Intel, AOL, Adobe and a whole community of photofinishers had thus been mobilized by Kodak. However, at least two major challenges still remained. The first was convincing photofinishers of the eventual success of Picture CD so that they bought the developing equipment, itself necessary to ensure the technology's success; and second was convincing PC manufacturers to include a CD drive with new computers. The latter was more difficult as a drive towards smaller, lighter, laptops and notebook computers was leading to the elimination of built-in drives and inclusion of PCMCIA card readers which were much lighter.

The issue of connectivity no longer represented a simple contention between traditional and digital technology. Instead, the issue has already led to the entrance of several new stakeholders, leading to a transformation of the photographic field. As images proliferated on the Internet, several other stakeholders joined the expanding field, providing services such as storage space on the Web or new formats to capture and store images. Indeed, a key thrust of Kodak's advertising was now the storage possibilities. Kodak stressed that many customers would use Picture CD to organize and store family pictures over the years. Television ads, for instance, poked fun at people who keep their pictures in old shoeboxes stuffed in closets.

In addition, Picture CDs came with hard prints. As discussed before, the issue of hard prints was one of the first to be raised after the introduction of electronic cameras. In the early 1980s, printing images was a prohibitively expensive notion. This shortcoming continued well into the 1990s. The relatively high price of color printers and the already poor resolution of digital images led industry executives and experts to conclude that the age of digital cameras was a long way in the future. Kodak's Manager for Public

Relations, Joseph Runde echoed the views of many when he remarked: "Digital cameras are not going to take off in the near future, I think because they are still complex and the prints are mostly terrible. Also, to print them it takes forever" (Interview with author, March, 1999).

One basic assumption underlying the industry that I encountered again and again was that consumers will always want hard copies of their photos. According to the *PMA Strategy Report* (1991), the industry needed "to build on this assumption and fortify their strategic plans accordingly. It was the job of the photo retailer, argued the report, to help the consumer appreciate the range of photo/ imaging products and services that exist, and to aggressively upgrade the customer's taste" (*PMA 1991 Strategy Report*).

Vanscoyk of Minolta explained,

> In photography, there are functional vs. emotional values. There is also short-term versus long-term use....It is clear the bulk of our business is situated in the emotional segment. The functional half is more the commercial and business-to-business part, microfilm, the graphic arts and printing business. In the short-term emotional segment, we find greeting cards, sticker prints, personal photographic invitations and thank you notes, but also Internet and PC imaging. ....In the long-term use with emotional value, we see silver halide is still, by far, the prevalent and preferred technology (Interview with author, March, 1999).

The en masse conversion of people from using slides to color negative film was often cited as proof that people wanted hard prints. As Kodak's CEO Colby Chandler remarked: "People like color prints. In the early 1970s, nearly one-third of the amateur pictures made in this country were shot on slide films. Today, fewer than 15 percent fall into that category." (*Business Week*, 1982) To Chandler and many others in the photographic industry, it was inconceivable that people's 'need' to touch, feel, and pass around hard prints could change. Indeed, they argued, people had preferred prints over slides and there was no reason for them to go back.

Finally, incumbents emphasized digital imaging as being too complex. For instance, Johanne Mussche (President of PMA) argued,

> "[F]or a large majority of our customer base, silver halide will be the system of choice. Our typical customer is a mother with two full-time jobs (professional and household). Can you imagine her, coping with all the equipment and instructions, and spending the time to produce her own prints, when she can buy the complete service conveniently and cheaply at any corner of any street, or by mail? No. The more so since we can provide her with a digital copy at a very low cost, if she wants to use these pictures for email, electronic storage or home printing" (*Photo Marketing Magazine, February, 1999*).

In fact, several advertisements poked fun at the apparent complexity associated with them by satirical slogans such as "You press the button, then click the mouse 200 times, and we do the rest."[56] Jon Seinkewicz, V.P Marketing, Consumer Products Division, Minolta Corporation stated the difficulties that beset digital cameras as follows,

> "[T]aking pictures with digital cameras is much more complex and cumbersome than anything else right now. The infrastructure to support the digital technology is simply not in place currently, and the photographic experience for the average consumer is completely different. And as long as digital technology does not reproduce the same experience for the consumer, it cannot succeed. And moreover, the quality of the images is poor as we speak, and the high costs are simply not justifiable. For 35mm you can get your pictures back in one hour or even less. This convenience is still not available in digital. Unless we see a digital camera with excellent results for something like a hundred dollars, it has little potential. Keep in mind that the average American makes less than

[56] This was obviously a parody of Kodak's earlier slogan "You press the button, we do the rest."

$35,000 a year and cannot afford a camera, computer and printer all of high quality, yet" (Interview with author, March, 1999).

Photography in a Different Light: Tactics of the New Entrants

While stakeholders of roll-film struggled to perpetuate the existing understanding of photography, new entrants, led by Sony, cast the issue in a different light. While they did not have Kodak's clout or the brand identification, Fuji or any of the camera manufacturers, they devised innovative strategies to get around these handicaps. Similarly, they 'problematized' (Latour, 1991) photography, framing it in the context of connectivity/ sharing, efficiency /electronic storage, and the infinite possibilities. At the same time, they enlisted the support of various existing institutions and stakeholders to entrench the new technology.

Take quality, for instance. With digital cameras, the measure of quality became increasingly unambiguous. Any camera that produced images of more than one million pixels was called a 'mega-pixel' camera. Soon the term became a black box for consumers connoting a high-resolution camera; several times comparisons were only made among various mega-pixel digital cameras rather than with traditional cameras. Another way in which the understanding of 'quality' was altered was by leveraging the facility of modification. Through easily available software users could 'improve' their images by removing 'red-eye,' unwanted objects from the composition or altering the image in an infinite number of other ways. Thus, the definition of quality was implicitly extended beyond the traditional one based mereiy on resolution to encompass several other aspects. Naturally, this 'improvement' in quality - in other words altering the image, an unacceptable proposition to many- was only possible through digitized images.

However, since digitized images are also available from Picture CD, attempts are being made to restructure the consumption chain by eliminating the PC. Also, as mentioned before, complexity is often linked with the necessity of a PC in the chain. Tackling this issue head-on, Minolta announced a digital camera model with a built-in modem and photo-altering software. If successful, it could alter the direction of the emerging institutional field, concentrating several major activities involving software, emailing and storage within one unit: the camera.

If the purpose of photography is to share images with people, digital cameras offer a simpler path than traditional cameras. With the proliferation of PCs and later, the Internet, digital cameras are no longer judged on the basis of whether it is 'simple' to take images, but on the grounds that they make emailing images a simple, one-step process. The images are downloaded from the camera to a PC and emailed; with Minolta's innovation, even the PC may disappear. Similarly, the cut/delete feature that allowed users to retain only those images that they wished to save, the writing feature or recording sound bites with photos and more seem to outweigh the slightly greater complexity and price that users had to pay for digital cameras.

Moreover, new entrants emphasized the fact that digital cameras removed two major, expensive activities from photography: buying and developing/ processing film. This freed the user from a recurring expense. The challenge was to make the user question the need to make this expense repeatedly. Michael McNamara, Technology Editor, *Popular Photography Magazine*, for instance argued that "right now the film-based culture is really well set. Consumers don't even question the fact that they have to buy film each time. It is most convenient for them."[57] Through advertisements, digital camera manufacturers reminded consumers of the possibility of infinite images for free. Advertisements focused on the users' ability to capture an infinite number of images while deleting the ones they did not like. The best example of such advertising came from Kodak's own digital camera division. It showed a girl posing coyly on a couch, with the headlines: "You finally captured the perfect smile. Now you can erase the 20 bad ones."

Contrary to common perception in the industry, the traditional and digital technologies were not competing on the same evaluation criteria, but instead trying to create separate criteria. Darin Pepple, Product manager at Fuji Film described this as follows:

[57] Author's interview with Mike McNamara (1999).

It is interesting that the film companies and camera companies are emphasizing great prints, while the computer industry is really hyping up the web, connectivity, MPGG video, high powered digital zooms and what not. They are trying to speak to another side of the consumer through another channel: electronics. Or they are selling through the web. All these things frame the camera differently (Interview with author, March, 1999).

It seemed to be working. As the shape, characteristics, associations and uses of a camera changed, slight changes were already noticeable in how people understood cameras and photography. No longer were traditional criteria for performance accepted without question. A complicated mosaic of technologies was emerging in the photographic field (Table 7.4).

Table 7.4: Competing Technologies

		Technologies		
Features	35mm	APS	Picture CD	Digital
Average Price	$100-300	$200-400	$10	$300-500
Recurring Expenses	Film/ Developing	Film/ Developing	Film/ Developing	None
Convenience	Highly Convenient	Highly Convenient	Convenient	Convenient
Hard Prints	Easily/cheaply Available	Easily/Cheaply Available in Different Sizes	Available with CD	Difficult to Get
Digitized Images	Images need to be Scanned	Images need to be Scanned	Images are Digitized	Camera takes Digital Images
Emailing Images	Scan First	Scan First	Need CD Drive	Simple
Enhancing Images	Need Software/ Scanner/ PC	Need Software/ Scanner/ PC	Software included on CD/ Need PC	Need PC although several features available on Cameras
Limit on Number of Images	Limit set by exposures in film	Limit set by exposures in film	Limit set by exposures in film	No limit
Peripherals Needed	None	None	PC + CD drive	Normally used with PC

Cut/delete images	None	None	Only on PC	Available in Camera
Write notes on Images	None	None	Only on PC	Available in Camera
Record Sound Bites	None	None	Only on PC	Available in Camera
Email Images from Camera	None	None	None	Available in some Cameras
Storage Medium	Film	Film	Film/CD	No universal medium yet
Lens can be Separated from Body[58]	Never	Never	Never	In some models

Primary Sources: Digital Imaging Association Reports.

Moreover, new norms evolved alongside the technology. For instance, a *Digital Imaging Association* survey showed that already all owners of digital cameras were showing a marked shift in their use of digital images. When asked how household members used the images imported into their home computers, 47.6% replied that the images were mainly emailed to friends. Three years ago, half that number had pointed to emailing as the primary use of images (Table 7.5). On the other hand, the number who printed out their images had gone down. Thus there was a marked change in the usage of images. People had moved on to a new use of images, from storing them in albums to virtual sharing. It was clear that a new norm was 'co-evolving' with the technology. The assumptions that customers would never give up hard prints was unraveling and challenging the credibility of one of the most frequently voiced criticisms of digital imaging: its inability to provide good quality prints cheaply. Similarly, as Table 7.1 depicts, while the use of all other cameras was concentrated during vacation periods, digital cameras were being used around the year. This shows that digital cameras are being used to take images of non-traditional subjects and in a variety of different venues. Again, this reflects a marked difference in the practice of photography.

[58] This is possible because in digital cameras, the lens (where image is scanned) and the body (where the image is converted and stored) only have to be connected through a wire. The LCD behind the camera body shows what the lens sees (making it possible to take pictures over walls, around corners etc.). In chemical-based photography, the lens has to be in front of the film, so separating the two is not possible.

Table 7.5: Use of Images Imported into Home Computers

(Percentage of Households)		
Activity	**1996**	**1999**
Print out at home	52.50	50.00
Send out on Email	23.00	47.60
Print on letters	44.30	18.70
Produce greeting cards	36.40	22.90

Source: *Digital Imaging Consumer Survey*, 2000.

Finally, Sony's introduction of memory-stick added a new dimension to the emerging picture that, extending the institutional field to the electronics industry. Like the Picture CD, the memory-stick was a storage unit, which could soon, if Sony had its way, be used in any electronic device. Through this move Sony had introduced a new source of externalities in the industry, in an attempt to create a bandwagon. Sony had cleverly leveraged its strengths in electronics in photography, while attempting to position its proprietary product at the heart of an expanding open network. Moreover, well aware of the threat that the Picture CD posed - because it came with hard prints, while converting digital images into hard prints was an impossibly difficult and expensive job - Sony introduced a new product: cyber-frames. Cyber frames were just like ordinary frames, except that they displayed digital images. Sony's memory-stick could be inserted in a frame and one by one, it displayed all the images on the stick.While it was too early to forecast how the market would receive this product, if successful, it could drastically change people's institutionalized relationship with hard prints.

CONCLUSION

To conclude, several changes had appeared in the institutional field since 1981. For instance, the imaging field had grown to occupy a space overlapping several existing institutional fields, including those formed around cameras, photofinishing, computers, semiconductors, printers, the Internet and several other technologies. The evolution of this field, however, was not driven solely by technological concerns, or by the desire to meet some well-defined customer needs. Instead, it was a far more amorphous and complex process where the technology evolved as a resultant of several decisions taken on technological, institutional, and strategic grounds. Alliances proved to be a most important factor driving this process. For instance, one key development in this respect has been the formation of the Digital Imaging Group. The DIG is working to build the future of imaging. It was founded by nine companies: Intel, IBM, Adobe, Live Picture, Fuji, Cannon, HP, Kodak and Microsoft. Several other companies have joined since including Polaroid and Konica.

An important development in the evolution of the institutional field was the concentration of various activities and parameters of quality within the camera. Whereas in the past the locus of quality was distributed across film, camera and photofinishing firms (or industries, if we go by SIC codes), it had now become concentrated in the camera. In this manner, digital cameras were embodying the interests of several hundred stakeholders. Naturally, the more interests digital cameras come to embody, the more stable they become.

However, many of the technologies that had emerged in recent years were still 'bare' meaning that norms or routines had not yet arisen to properly contextualize them. Their meaning was still ambiguous. While the features were 'functionally' useful such as the ability to cut/delete or enhance photos, record sound bites, write notes on pictures, it was not certain how much these features were worth or why anybody would do it.. The situation was analogous to the one experienced when bicycles were introduced (Pinch and Bijker, 1987), automobiles replaced horse-carriages, or PCs replaced word processors (Utterback, 1994). What the new features introduced by digital cameras were worth remains/remained unclear. It was only as a context developed around these innovations that people were able to make sense of them. And such a context could only develop as externalities across institutional fields were created. Digital cameras represented the convergence of several technologies embodying the interests of several stakeholders traditionally considered to be in different institutional fields. A new institutional field was thus emerging around digital imaging, which itself was evolving in a context where the existing notions of photography interacted with changing lifestyles and technological possibilities. Naturally, as emerging trends crystallized they would assume the form of normative and eventually cognitive sense-making devices to future users.

The digital imaging case provides significant insights into our guiding research questions. For instance, it lends much support to our initial argument that radically different technologies could not be inherently superior or inferior. Superiority, instead, is a trait acquired through firm-strategies that interact with institutional and technological factors. Similarly, it highlights the complex process, at once social and technical, through which the field undergoes a metamorphosis, shaping around the co-evolving social and technological changes. Finally, it puts managerial agency in perspective by highlighting the role that the strategic introduction of Picture CD or memory-stick are playing in shaping the path around which technology is evolving. Thus, in contrast to Hoffman's (1999) thesis, the formation of the new field did not appear to be occurring only around issues. Instead it was the mutual interaction of technology, issues, externalities and social changes that provided the nexus for the emerging institutional field.

Apart from these insights, the case study led to the emergence of several new, important questions. For instance, why had the MAVICA been so successful? Was it because of simplicity? When does simplicity override functionality? Is it possible to predict which subsystem of an emerging technological product would become 'core' (Tushman and Rosenkopf, 1994)? And above all, how useful is the category 'industry' during times of radical technological change? Is Sony in or out of the photographic industry (in the 1999 PMA conference, Sony always referred to itself as an insider, but all incumbents referred to it as an outsider? Does it matter if we consider a competitor within or outside our industry? The next chapter develops a theoretical understanding of these issues.

CHAPTER 8: TOWARDS AN INTERPRETIVE THEORY OF TECHNOLOGY EVOLUTION

"I don't write a book so that it will be the final word; I write a book so that other books are possible, not necessarily written by me."

Michel Foucault[59]

In this chapter I first revisit the guiding research questions and briefly summarize the findings from the four case studies. In the next section, I develop a theory of technology evolution which puts the current findings in a perspective developed with existing insights from various research streams. As much as possible, I have sought to make the resulting theory neither 'oversocialized' nor 'undersocialized' (Granovetter, 1985). Like Foucault, I do not claim this theory to be the final word in technological evolution, but simply another perspective that has emerged out of this particular study. However, through this particular perspective, researchers and managers can develop a substantially different understanding of how and why certain technologies succeed while others do not.

FINDINGS

Inherent vs. Acquired Superiority

The question of inherent vs. acquired superiority was raised because of a tendency in existing literature to either attribute eventual success/ failure to inherent attributes of a technology. Or, in case the 'superior' technology did not succeed, to suggest that strategy (Teece, 1988), socio-political forces (Anderson and Tushman, 1997), path dependency (Arthur, 1989), or clout (McGrath et al, 1992) were responsible for the outcome. Recent

[59] 'Entretien avec Michel Foucault', [Dits et Ecrits vol II Paris: Gallimard, 1994: pp.157].

research, especially Christensen (1997), however, has put things in a different perspective by concluding that after radical, competence-destroying discontinuities, the needs of customers are undefined and hence, by implication, a technology cannot be judged superior or inferior at that stage. The photographic industry case confirms Christensen's observation: it is a mistake to judge technologies as superior or inferior right after a radical discontinuity (Christensen, 1997). As Arthur (1989) has argued, when a new engineering or economic possibility comes along, there are usually several ways to carry it through. In the 1890s the motor carriage could be powered by steam, gasoline, or by electric batteries. While gasoline would seem the obviously superior choice now, it was not then. Similarly, to some, digital cameras may seem obviously superior to traditional cameras, but it has taken them 20 years to gain a 3-4% market share, and because of their dependent relationship with computers, it is not clear if they will ever be dominant. Finally, when the camcorder arrived, they were 'superior' in every respect to traditional cameras. Not only did they produce pictures, but also provided motion and sound Reasonably, experts pronounced the end of still cameras. However, camcorders could only carve out a specific niche in the market.

Table 8.1 summarizes the four case studies. As is readily apparent, in each case, the final outcome was neither a direct result of technological prowess, nor predictable right after the discontinuity.

Table 8.1: 'Performance' and Outcome of New Technology Initiatives

New Technology	Performance on Existing Evaluation Criteria	Initial Response	Long-term Performance
Roll Film-Kodak	Since photography was only practiced by professionals and serious amateurs at the time, quality of image was of paramount importance. Roll film produced pictures of poor quality.	Roll film was quickly rejected by the market on its first outing.	Later, Kodak was able to structure a new market around its technology, with a completely different set of evaluation criteria.
Instant-Polaroid	Polaroid's quality was inferior to roll-	Instant photography	Polaroid was unable (or unwilling) to

	film, and the process was messy. Other than that, it was difficult to compare the two very different technologies.	enjoyed dramatic success, despite poor quality images and a messy process.	build a strong network around its technology, leading to its decline.
Disc-Kodak	The disc was capable of producing better images than Kodak's existing 110mm cameras. At the same time, it was simpler, smaller and technologically more sophisticated than other available models.	For the first 1-2 years, sales broke all previous records of product success.	The disc fizzled out within five years after Kodak was unable to deliver on the claims that were made. Moreover, it faced increasing competition from the open 35mm standard.
Digital Imaging	Digital cameras were expensive, complicated and produced images of extremely poor resolution.	Sales were very poor throughout the 1980s. They picked up slightly in the 1990s, but by 1998, digital cameras could only acquire about 4-5% market share in the camera market.	As the context around digital cameras changes, the features that they offer are becoming increasingly attractive. However, other technologies, such as Picture CD are providing competition to them.

Do Random Events Lead to Superiority?

Path dependency theorists, Arthur (1989; 1996) in particular, have argued that small events that occur soon after a radical discontinuity, tend to have a disproportionate influence on a technology's chances of success. Any such event can lead to initial acceptance of a technology whereupon increasing returns to adoption kick in and the technology comes to dominate. In the present study, it is difficult to confirm or refute this since only in the roll film study was the technology able to achieved dominance. However, in that one case, Kodak's systematic structuring of a new market appeared quite clearly responsible for the prevalence of roll film cameras. No major 'random' events were noticed that could have led to the dominance of roll film. Not only did Kodak completely redefine photography for the new market but it created social institutions which became an integral part of what photography was. Moreover, Kodak systematically eliminated all competition through purchasing patents or acquiring competitors in order to protect its original technology from unwanted competition.

There was evidence for questioning the path dependency claim, however. According to path dependency theorists, initial acceptance, due to any reason, should generate bandwagon effects, leading to the eventual prevalence of an 'inferior' technology. In the case of the disc camera 25 million cameras were sold within 5 years,. The first year of its sales, the format captured 30% of the market. Why were bandwagon effects not witnessed? What prevented increasing returns to adoption from kicking in?

How Do Changes in Evaluation Criteria Come About?

While much popular literature considers price, simplicity, image quality or technological sophistication as the 'evaluation criteria' that the masses employ to judge a new camera, I discovered that evaluation criteria were part of the broader interpretive schema, which people employed to make sense of the technology (Weick, 1995). Changing evaluation criteria requires restructuring the field, or building one's goals into the normative rules of practice. An excellent illustration of this is the success of the roll film. Kodak's technology did not meet any 'unfulfilled needs', nor did convenience simply replace quality as the key criterion in the roll film case. Rather, Kodak redefined the very practice of photography. The new evaluation criteria derived from the dynamics of the mass market, to which photography was a far cry from 'accurate representation of objects.' Polaroid, on the other hand, failed to do that. Finally, in the digital case, we see how a group of electronics firms, led by Sony, is encouraging such a shift in normative practices. Already, some changes are noticeable in the patterns, which have formed around photography over the years, including an increasing propensity to email images rather than printing them and storing images electronically rather than in albums.

Impetus for Change

Institutional theorists have long suggested that the impetus for change is either external to institutional fields or comes from large institutional players who force their immediate relational networks to adapt to their practices (Meyer and Rowan 1977). The roll film, disc and digital cases furthered our understanding of where impetus for change comes from and why. Whereas impetus was both externally and internally generated, depending upon the case, by no means was sponsorship by a powerful institutional entrepreneur a guarantee of success. For instance, in the case of disc cameras, Kodak's monopolistic clout was not sufficient to make disc technology dominant. On the other hand, Polaroid, a small company from outside the industry, went on to create major inroads into Kodak's traditional monopoly. Table 8.2 summarizes the various technologies and the impetus for change in each case.

Table 8.2: Impetus for Change in the Photographic Industry

Radical New Technology	Impetus for Change	Reasons behind Change
Roll Film	Kodak, a leading firm in the dry-plate dominated industry, introduced roll film.	Kodak's market position in dry-plate business was squeezed. Kodak was not as immersed in the 'professional' culture of photography as its competitors.
Polaroid-Instant	Polaroid, an outsider, introduced Instant imaging.	Polaroid's naivety led it to pursue a radically new idea.
Disc	Kodak, the most powerful institutional player introduced the disc.	Kodak's desire to perpetuate its control over a systemic photography market. Kodak's response to 35mm (expensive SLR cameras) and electronic cameras.
Digital	Introduced by Sony, an outsider.	To leverage Sony's capabilities in a new field.

Insights into the success or failure of certain technologies provided by institutional theory are limited. The latter theory limits itself to suggesting that dominant institutional players have the best chance of forcing their immediate relational networks to adapt to their practices, and thus building their goals and procedures directly into society as institutional rules, (Meyer and Rowan, 1977) but does not quite explain how. This point is discussed in the next section; it develops a theory by connecting insights from this research with existing models and theories of technology change.

Emergence of Institutional Fields and Issues

Technology management researchers (Utterback, 1994; Tushman and Anderson, 1986) as well as path dependency theorists (Arthur, 1989; 1996) have acknowledged the great difficulties that lie in explaining exactly how some designs come to dominate. Government intervention, technological developments, social factors, strategic alliances, collateral assets, and several other contingencies combine to 'select' a design. This process, the emergence of the dominant design, usually results in significant changes in the institutional field, destroying existing incremental innovation patterns, threatening to render existing capabilities useless, and leading to the entry as well as exit of many players. The institutional aspect of this drastic change led us to explore insights generated by institutional theorists regarding how new fields emerge in response to disruptive events (Hoffman, 1999). This line of inquiry was very fruitful, and observing the manner in which issues were identified, projected and framed provided invaluable insights into the evolution of technology.

However, as useful as Hoffman's perspective was, my findings questioned his primary conclusion, that institutional fields evolve not around technologies but around issues, as well as his core assumption that disruptive events always led to reconfiguration or emergence of institutional fields. To begin with, his focus on disruptive 'events' seems to connote a certain assurance that a particular event will indeed lead to disruption[60].

[60] It is only because we have the benefit of hindsight in all four cases, that I have labeled the technological shifts as disruptive. If a technological innovation or event occurs today, it can at best only be called 'potentially disruptive.'

This, as we have observed in the empirical part of this study, is a fallacy. Events are nothing more than events. Similarly, technological innovations can only be potentially disruptive. Thus, the roll-film innovation was not in itself a disruptive event. Indeed, Warnerke had already developed the basic design and even when Kodak introduced it, it failed to create any ripples in the market. Instead, the disruption was created by Kodak's efforts to popularize the design. Was the invention of the roll film the disruptive event, or Kodak's introduction of it? Or was it Kodak's decision to reposition it to the mass market after it had failed in the professional one? Indeed, there was no *one* event that could be pinpointed for being responsible for disrupting the field. Several events combined, most of them engineered by Kodak changed the field. Similarly, in the digital imaging case, the introduction of digital cameras could hardly be categorized as a disruptive event. After twenty years, digital cameras have been able to acquire less than 5% share in the camera market. Sony has struggled, along with a growing number of firms, for these twenty years to *make* it a disruptive event. By using Hoffman's approach, disruptive events can only be recognized in retrospect which renders this approach almost useless to managers or scholars trying to understand present-day change.

Hoffman's conclusion that institutional fields grow around issues and *not* technologies was not reflected by our data. Rather than forming around issues, new institutional fields in all cases except disc camera, were shaped by the ongoing structurational (Giddens, 1984) relationship between technology and issues which was mediated by the technology's sponsor, Kodak. Partly it *was* the discursive struggle that took place over issues that shaped the emerging field but at the same time, technological changes were responsible for institutional evolution. Where issues drove technological evolution, technological developments which were sometimes unrelated to the field generated more issues, or complicated existing issues. For instance, PC diffusion and Internet access had a significant effect on the evolution of digital imaging. The introduction of these technologies automatically led to new configurations within the institutional field and to the entrance of several new players. That the majority of the firms attending the annual conference of the 1999 Photo Marketing Association International were 'outsiders' - electronics, software, hardware industry players - rather than film or camera manufacturers is illustrative of technology's ability to bridge industries. Moreover, when discursive struggles are settled, usually the interests and beliefs of a particular institutional field come to be embodied in a technology, rather than an issue. Thus, while it is true to say that issues shape fields, it is equally true that it is only in conjunction with technological developments that issues are able to do that. Similarly, fields are held together by the consensus that emerges out of discursive struggles over issues and which is usually embodied by a technology.

Hoffman admitted that while he had shown that issues shaped institutional fields, his research "could not prove a causal connection between the events detected and the institutional change that followed." (Hoffman:1999: 367) The present study has several insights to offer regarding this causal connection and these will be presented in the next session.

SYNTHESIS AND THEORY DEVELOPMENT

In this section, a theory of technology evolution is developed which weaves the findings with theoretical insights from a variety of research streams including technology management theory (Abernathy and Utterback, 1978; Tushman and Anderson, 1986; Utterback, 1994) path dependency (Arthur, 1989; Langlois and Robertson, 1992), institutional theory (DiMaggio and Powell, 1983; Leblebici et al, 1995; Hoffman, 1999), structuration (Giddens, 1979; 1984; Orlikowski, 1992) and actor network theory (Latour, 1991; Callon, 1995). Specifically, I build a theoretical understanding of how designs acquire dominance, and why some designs stay dominant for longer periods of time, while others fail in that respect.

The Acquisition of Dominance

What is required for a design to attain dominance may be understood by drawing on a rapidly strengthening viewpoint in the sociological literature on technology, actor-network theory or ANT (Callon, 1986; Latour, 1987; Law, 1999). ANT argues that designs must not be considered superior or inferior at the beginning of the era of ferment.

Rather, they should be seen only as claims vying to become 'facts'[61] (Fig. 2). It is further argued (Latour, 1986; 1987; Callon, 1996) that for claims to be converted into facts, all controversies that inevitably accompany new claims, must be settled, and the design 'black boxed.' Black box is a term used by cyberneticians to describe a piece of machinery which is complex, and about which they need to know nothing but its input and output (Latour, 1990). It is like a 'fact,' which needs to be treated as such. It contains several years of advancement in research, and is now widely accepted to be the 'best' possible solution to a particular problem. Finally, it is closed because all further discussion over it is redundant. Simply, a design is successful when it assumes the status of a black box. At this stage the several arbitrary choices that constitute the particular nature of the design are hidden from the customer's view, and he/she accepts it because it appears to serve his/her interests in the best possible way.

For the majority of the world's population (those who are still ignorant of digital imaging), the roll-film camera is a black box. The basic design of the camera as well as the principle on which it is based is taken for granted. It is considered the most feasible way of taking pictures and all discussion on its design has ended. How the camera works and if there is a better way to capture images are moot questions. When people go to buy cameras they rarely ask if it takes roll film. Similarly, they seldom inquire about the availability of development services for the film, whatever format it may be. The routines that have developed around the use of the camera are part of the black box. For instance, the requirement of buying films (12, 24 or 36 exposures) and later paying again for its development is considered part of photography. In actor-network terms, the roll-film camera and the concept of photography that it embodies, has been black boxed.

But before a design can become a black box, its proponent has to settle the numerous controversies that question the various choices -of materials, architecture, components, features and so on - embodied in it. These controversies could range from the feasibility of the design for currently valued activities, to the actual 'need' for the design to the easy and cheap availability of various related artifacts. For instance, several

[61] The design may be developed further, used in multiple contexts and leveraged to support other designs, but it is nevertheless treated as a 'fact.' The internal combustion engine, for example, is considered the best alternative for providing power in automobiles, for a fact!

aspects of the roll film camera were questioned when it was first introduced. The film, the complex maneuvering required to get the film out of the camera, the poor quality images, the blistering of the film were only a few salient issues among several others that were raised. In order to become a black box, Kodak had to settle these controversies that surrounded the nascent design. Similarly, Polaroid's instant technology was criticized for the 'messy' process through which pictures were obtained, the high price of the cameras and the loss of control for the photographer. Finally, digital cameras have been under scrutiny for several years for their poor quality, absence of hard prints, high prices and dependence on computers.

According to Latour, controversies are settled by harnessing the support of other 'facts' and agents. Since new facts are built upon old ones, association with existing facts serves to convert a discontinuous or 'disruptive' technology into a continuous or 'sustaining' technology (Moore, 1995; Christensen, 1997). Conversely, associations with agents ensure their support for the nascent design. Thus a new design acquires value through the construction of a *chain of associations* that constitutes both agents as well as facts. Such a view expands the rather narrow concept of resources in the resource dependence view that generally includes only tangible, easily recognizable sources of power such as government regulation, technological competencies, access to markets and distribution networks, to include any structure that contributes to the conversion of a claim into a fact.

Accordingly, we may argue that factualization is essentially a process of building regularity or routines (Nelson and Winter, 1982) around new designs, accomplished through the creation of links with 'regular' structures. Regular structures are simply entities that lend stability, continuity and value to a nascent design. These comprise both agents and inanimate resources or schemas. This argument derives from an appreciation of structuration theory (Giddens, 1984). Social theorists (Giddens, 1984; Porpora, 1989; Sewell, 1992) argue that the choice that agents make in such situations is a function of structural influences on agents' actions. Formally, Giddens defines structures as "rules and resources, recursively implicated in the reproduction of social systems" (1984: 377). Thus the concept of structure refers to any factor that influences action (Giddens, 1984). Following Orlikowski (1992) we may assume technologies to be structures. However, not everything that influences action is a structure. Structures are differentiated from a general set of contingencies by the regularity that they possess (Mauws and Phillips, 1998). In other words, they are influences that are relatively stable (e.g., Collins, 1981). Examples of common relevant structures for nascent designs include the existing rules governing relationships among industry members, jointly adopted standards, brand names, or technological artifacts. However, by no means is the list limited to these. Indeed, any social structure can perform the function of adding stability to nascent designs.

It is important to note that the relationship between social action and regular structures is a recursive one (Giddens, 1979; 1984). Through their actions, people enact and reproduce structures, and by guiding action, structures maintain regularity and predictability in social situations. Consequently, association of a nascent design with regular structures may have a regularizing effect on it. Association with a regular structure could constitute incorporation of an existing technological 'fact' within the design itself or in the usage pattern of the design, or an alliance, ranging from a simple licensing contract to a joint effort for technology development, with a discrete agent[62]. In both cases, the link must be obvious to the customer so that the nascent design can benefit from what could be called a "stability-spillover effect." In other words, association with regular structures adds regularity to a nascent design.

Regularity in the Photographic Industry

Take the case of Sony MAVICA. The MAVICA employed 1.44 MB floppy disks as storage devices compared to Kodak who employed CompactFlash and Smart Media cards, which could store vastly more amounts of visual data than floppies. However, Sony's Mavica quickly captured 40% of the market in digital cameras. The industry was dumbfounded. Soon, however, it was rationalizing Sony's success in terms of the

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[62] While management research has emphasized more explicit influences on selection such as compatibility, market clout, or the role of regulatory institutions, relationships of a new technology with existing technologies, social institutions, or technological 'facts' as an important influence in the selection process has largely been neglected.

inherent simplicity of the floppy disk. Not convinced by the "simplicity" explanation, I wish to argue that rather than simplicity of the design, it was actually the 'regularity' of it that propelled the MAVICA to success.

The floppy disk is a highly institutionalized product; it is also a black box. Introduced in 1980, interestingly also by Sony, the 3 ½ inch disks did not automatically become the predominant method of storage in PCs. Indeed, during the early 1980's many competing formats tried to outsell with the 3.5 inch drives. From various companies there were 2.0, 2.5, 2.8, 3.0, 3.25, and 4.0 inch formats. However, in a manner similar to the cases of technological evolution discussed in this study, the industry adopted on the 3.5 inch format, which is now standardized and manufactured by many companies. Today's standard 3.5 inch diskettes hold a formatted capacity of about 1.44 megabytes. When introduced, the 3.5 inch floppy simply represented a claim. In order to become a 'fact' it underwent several changes to settle controversies and incorporate requirements of an evolving institutional field. For instance, the primary factor, which caused designers to reduce the size and cost of floppies, was the introduction and evolution of the personal computer. It was in the personal computer market that the low cost, mass produced floppy drive found its first real home. Very quickly the floppy became the standard method of exchanging data between personal computers. It also became the popular method of storing moderate amounts of information outside of the computer's hard drive. Diskettes are small, inexpensive, readily available, easy to store, and have a good shelf life. Moreover, an enormous network of PCs has formed around the disk leading to significant positive externalities.

Furthermore, routines have been established around the use of 3.5 inch disks much like they have emerged and institutionalized around roll film. Customers, new and old, know exactly what to do with these disks, how to use them, where to store them, how to protect them and so on. In other words, 3.5 inch floppies are a 'regular' structure. And according to the regularity argument, any nascent technology, which incorporates a regular structure, must benefit from 'stability-spillover' effects. The MAVICA was a radical technology with familiar components. Thus, it was less disrupting than competing designs that comprised unfamiliar components, although technically more advanced ones. Much like how the Photo CD tried to bridge the familiar and the unfamiliar, smart media cards or other devices tried in vain to introduce floppy disk adapters, devices which convert the card into a floppy disk so that the 3.5 inch drive can read them. It is indeed interesting that with the second generation MAVICA, Sony has once again introduced a memory storage device, the memory stick, which is functionally inferior (it was introduced with a capacity of 8 MB) but brings major stability-spillover effects by bridging the camera with major technological institutions in the electronics field.

Nascent designs thus gain an advantage by incorporating regular structures starting from the early stage of product design. For instance, consider the Polaroid SX-70 case. In 1972, Polaroid introduced the SX-70 model to rave reviews. The camera was dubbed the ultimate one-step mechanism for taking high quality pictures and was acknowledged by experts to be perhaps the greatest innovation in the field of photography ever. However, its highly innovative design broke away from traditional standards, disruptive existing routines and introducing irregularity in the field. The camera comprised several components that were required new understandings, both technical and social, manufacturing facilities, and capabilities. While several established players were stakeholders in Polaroid's previous designs including Kodak, the SX-70 forced Polaroid to internalize many of the services it has previously outsourced. The new design was driven by a quest for technological 'brilliance' instead of considerations of regularity and elimination of any disruption. Moreover, by sticking to a total control policy, and keeping all the new developments proprietary, Polaroid effectively eliminated any chances of regularizing the new design.

Similarly, in the disk camera, the introduction of disks, instead of film, contributed to irregularity. Several routines that had been established around the use, developing and printing of films were immediately broken. The most critical ones proved to be in the domain of photofinishers. Photofinishers found the development process for the disk entirely different from anything they had handled in production before. The "exceptionally tiny chemical tanks that were hard to keep in balance, special disc opening technique, printing frames that were so tiny they were impossible to preview, unusually heavy paper waste because it was inconceivable that a printer person would hit it on the first pass, and a different packaging routine" (Lansky, 1995) disrupted existing processes and required learning new ones. As a result, with most people having to retrain themselves to handle the new medium, the prints did not turn out as well as they did in the tests, where ideal conditions were present. Kodak's ultra-secretive policies and insular attitude towards the photofinishers did not help the situation either. There was little effort to make the disruption smoother for them, or to help them transcend the irregularity that they were introducing.

The argument may be raised that from such a perspective, the roll film camera was an even bigger irregularity, but still it succeeded. The case of roll film, however, contains one major difference: roll film cameras succeeded because Eastman was able to structure a new field around them. Within the incumbent institutional field, they were still criticized for their poor quality and for 'robbing' the photographer of all possibilities for creativity by internalizing the processing of film.

It is important here to distinguish between the institutional argument of legitimacy (DiMaggio and Powell, 1983; Tolbert and Zucker, 1996) and regular structures. While institutional theorists have emphasized the importance of legitimacy conferring agents for a long time, alliances made with regular structures are not only motivated by legitimacy concerns, although that is certainly one aspect of any relationship. For instance, many smaller firms that are part of the emerging digital imaging field wish to form relationships with Eastman Kodak to benefit from its brand name as well as clout; it could thus be argued that these organizations are seeking legitimacy, although relationships with Kodak obviously has significant economic implications for various reasons. Still, from a regularity perspective, a major motive behind enrolling agents in a network is economic and even functional. Similarly, agents join the network because of their own economic interests rather than merely out of legitimacy concerns.

Enrolment of Actors

So far I have argued that the enrolment of regular structures such as technological institutions, other dominant designs, or widely used standards contribute to building regularity around a nascent technology. However, in addition to such regular artifacts, claims may also need to be supported by other actors. As Wade (1995; 1996) suggests, competition among designs is actually a struggle for dominance among rival technological communities. A community which comprises inanimate structures that lack agency themselves as well as agents or actors is called an 'actor-network' by sociologists of technology (Latour, 1986; 1987; Callon, 1996) implying that the actor only exists because of the network and vice versa.

All technologies, competing for dominance in the beginning of the era of ferment, make claims of superiority. However, as technology management theorists (Tushman and Anderson, 1986; Utterback, 1994) as well as path dependency theorists (Arthur, 1989; Langlois and Robertson, 1992) suggest, a design does not have to be actually 'superior' in order to be widely adopted. In fact, designs, which are adopted, go on to become superior. Generating adoption, however, is not only a matter of convincing consumers. It also requires convincing other actors or agents to support a claim, regardless of its actual value. For this, the design must be modified to incorporate the interests of other stakeholders including service providers, component manufacturers, competitors, customers and other entities (Figure 8.1). Indeed, Cusumano et al's (1992) study of the evolution of the VHS standard in VCRs emphasizes JVC's willingness, in contrast to Sony's refusal,to let stakeholders modify the design as a key determinant of VHS's success. Without a chain of industry members committing resources to the provision of various parts and services needed to deliver on the claim, new claims have little probability of being converted into facts (Latour, 1987). Thus, the roll-film camera is a dominant design because of a chain of associations in which it is embedded and which constitutes the context in which it can remain dominant. In this context, film is cheap and widely available, cameras are simple to use and do not break down frequently, quick photofinishing services are widely available and affordable, and finally, preserving memories as pictures and displaying them is a valued activity. Obviously, these conditions needed to be satisfied before the roll-film camera could become dominant. It also implies that incumbents in the photographic industry pushing PhotoCD technology must create a similar chain of :photofinishers who must purchase equipment which can digitize and transfer images directly from the film to CDs; PC manufacturers, who must ship computers with built-in CD drives; and dominant software developers who must ensure compatibility between the two software.

By the same token, it may be argued that the SX-70 failed at least partly because Polaroid did not realize that designs are 'superior' only as long as they embody the interests of a support network. Before SX-70, Polaroid's cameras were part of a growing network, which included consumers, manufacturers, as well as other stakeholders such as the photography magazines, Wall Street and so on. This entire network was situated in an evolving organizational field where picture-taking was an increasingly popular activity, and users were seeking instant gratification. Thus, Polaroid's ability to cut the time and effort of getting pictures developed was becoming more and more valued. Moreover, consumers were well familiar with the workings of instant cameras; several camera manufacturers were producing instant cameras under license, and many hi-tech companies were involved in manufacturing various parts for them. The center of the institutional field was shifting gradually from traditional photography to instant photographic technology. These stakeholders had made substantial commitments to this technology and were interested in watching it blossom. With the SX-70, Polaroid broke off most of these relationships. In choosing to become a vertically integrated company, Polaroid alienated all its 'friends.' The radically new design of the SX-70 was driven more by the personal ambitions of Land, rather than by considerations of building a network around the technology. The design did not incorporate existing technological institutions (batteries or shutters, for example) and thus had no major stakeholders behind it. Moreover, it was composed of several radically different technologies, whose functional reliability had not even been proven yet. Yet Polaroid expected it to become institutionalized simply because of the Polaroid brand, and the state-of-the-art technology.

We have already discussed the case of disk cameras in the context of regularity. This highly praised technology again did not embody the interests of a support network, and thus represented essentially no one except Kodak. Indeed, when disk technology was being launched, the *British Journal of Photography* had hinted at the uncertainty that photofinishers were faced with(while maintaining that "although this feature is written before the large scale introduction of the camera, there should be no doubt as to its eventual popularity":

"The one group who could view this innovation with distrust are the processors. To be faced with a possible expenditure of over 100,000 pounds sterling just to get into the game on an economic level, does not, to most firms, seem an attractive proposition when equated with a possible 10% increase in films received" (*British Journal of Photography* Annual, 1981).

Perhaps even more importantly, Kodak never really considered photofinishers or other smaller stakeholders crucial to the success of its products. As discussed in the disc case, the reasons for the disc's failure, it seemed, lay not in the technology itself but outside it. While consumers obviously liked the technology and it fit well with the photography rituals, Kodak remained the sole force behind the technology. On the other hand, the open architecture of 35mm was attracting newcomers in throngs. The 35mm cameras were harder to use, still requiring some familiarity with controls, they were more difficult to load, weighed more, were larger in size, and produced photos that were not discernibly better than disc photos. While the technology was not as popular among the consumers as disc, they were much more attractive to players in the institutional field because of their non-proprietary nature and allowance for design modification.

That stakeholders must be enrolled during the era of ferment is not a new concept. In fact, much research in the resource-dependence view emphasizes the need for forming alliances for the acquisition of critical resources such as technological competence, legitimacy or access to distribution networks, capital, and new markets (Ulrich and Barney, 1984; Dunford, 1987; Oliver, 1991). However, a clear distinction has not been made between 'regularizing' alliances, and 'competence-enhancing' alliances. Relationships that an innovator makes for regularizing a design and delivering on the claim made, regardless of any measure of superiority fall under regularizing alliances. Similarly, licensing agreements, and relationships with manufacturers of derivative products are regularizing in the sense that they are all geared towards delivering on a particular claim. On the other hand, alliances between firms for the purpose of advancing the focal firm's technological capability fall under 'competence-enhancing' alliances. It implies that alliances made for the acquisition of resources that may be considered critical at the time, are only useful insofar they help the firm convert existing technology into a 'fact.' Thus contrary to popular belief, alliances with existing technologies, products, systems and other structures that have a regular influence on consumers' actions during the era of ferment will explain a technology's success better than 'competence-enhancing' alliances made for the acquisition of 'critical' competences.

Giving Meaning to New Technologies (Problematization)

All successful technologies carry meaning for their users, not only in terms of technical functionality, but also socially. For instance, cars are popularly understood as technological devices that enable mobility, allow fast travel, provide protection from the weather, and reflect the social status, or personality of the owner. The ubiquitous internal combustion engine is accepted without question and considered undoubtedly the most feasible alternative for powering the vehicle. Arthur (1989) even suggests this was not always the case and internal combustion engines were actually considered an inferior option by many at one time. The idea of a car, along with the technology embodied by it, is thus highly institutionalized. They are a socially sanctioned means of transportation from point A to point B. The ownership and use of cars, however, are not always functionally driven decisions. Indeed, it is common to observe people buying cars for social reasons, when they do not 'need' one, or even when they cannot afford one. Cars with more sophisticated features are not purchased because of the availability of high-tech devices, but because of the social meaning that is built around the acquisition of that particular artifacts.

It must be remembered that when first introduced, cars were considered a nuisance more than a useful innovation. Compared to the existing alternative for transportation, such as the horse cart, the cost of buying a car appeared exorbitantly high much like digital cameras are considered expensive compared to traditional camera). The radically new features that it offered did not make much sense to people, and the car had to undergo several transformations before it was sanctioned and popularly accepted. The photographic field provides further evidence of how radical new technologies strive to acquire meaning in attempts to increase acceptance in the market. It further indicates that this process is structurational. That is, technological advances and social meaning of a technology evolve in a recursive relationship. As I have discussed before, radically new technologies need to be articulated in terms of the everyday artifacts, routines and practices. They need to be given meaning in terms of existing and emerging institutional understandings. It is only then that they become comprehensible to customers.

The construction of meaning around a technology, however, does not seem to be a result of random events - at least from the evidence supplied by the photographic industry. Instead, it is the result of several forces exerted by players to define the new technology. Deliberately, or inadvertently, strategically or otherwise, players associate their nascent technologies with social institutions, market them in particular ways, sell them through particular channels and talk about them using particular vocabulary. All this creates meaning around the new technology. Naturally, as discussed in the previous section, the success of this effort depends upon the support that the proponent is able to harness behind the design. Since all firms are constrained by their existing competencies, they are more willing to alter some aspects of a technology rather than others in order to meet vague customer expectations, for example, Kodak does not wish to eliminate roll film, or make it unattractive to consumers. The alternative is to alter the evaluation criteria employed by the market to judge technologies. Garud and Rappa (1994) have suggested that technological designs co-evolve with evaluation routines. Evaluation routines are methods employed by researchers or inventors to test or validate a technology. Existing routines perpetuate existing technologies. At a macro-level, evaluation routines are transformed into evaluation criteria. These criteria are in fact measures of how well a particular technology meets a valued end. In case of radically new technologies, prevailing evaluation criteria invariably favor existing dominant designs (Christensen, 1997). Thus, under prevailing evaluation criteria, a radically new design cannot demonstrate its true potential, and unless it does so, attracting others to participate in developing the technology to a more advanced state is not possible. The only way out of this catch-22 situation is intervention by organizations to create new evaluation criteria that favor the new technology. Changing the existing evaluation criteria for any technology does not occur in isolation, however. It is part of a larger process which involves the creation of meaning around the nascent technology.

The success of Kodak's roll film is a perfect illustration of how Kodak constructed new meaning around the activity of photography, thereby changing its popularly employed evaluation criterion. As described in the roll film case, Kodak successfully negotiated various currents that existed in its environment to position photography as a social, popular and essential activity. By actively positioning its technology strategically with respect to various emerging understandings of family life, gender relations, and social behavior in general, Kodak was able to infuse photography with particular meanings. It was an everyday device that could (and should) be used both within and outside the home, by men or women, and which was (and should be) an essential companion on vacations, or any social occasion; and a necessary item for preserving visual memories. From a specialized activity, performed by a few, photography was transformed into a social activity carried out by millions, and the roll-film camera was the perfect device for such a purpose.

In contrast, Polaroid's strategy was different. During the 1950s and 60s, photography was increasingly becoming a popular activity, Kodak introduced the Instamatic in 1963. The Instamatic was a completely simple camera, which took a cartridge instead of a film, thus removing any chances of wrongly loading film. Through the Instamatic, much like the Brownie, Kodak was helping photography lose its 'serious' activity perception and truly become an activity for the masses. Polaroid, on the other hand, aimed to take the masses to photography, while making photography more technologically sophisticated. Polaroid's technology-focus diminished the ability of instant imaging to integrate with social norms as roll-film had managed previously. As opposed to Eastman's social engineering strategy, where technology was allowed to be defined in terms of social institutions, Polaroid's Land nurtured his technology in a laboratory, choosing to limit its definition to an 'art' and a 'serious,' reflective activity..

Kodak's strategy was inclusive; Polaroid's was exclusive. Kodak not only created a new class of photographers, ordinary people unfamiliar with the basis principles of photography, but encouraged the creation of social occasions where this new class could practice this activity, making photography a social event rather than an individual pursuit. In contrast, Polaroid encouraged photography as an individual activity, whereby the photographer could explore unknown territory through the lens. Polaroid cameras added an adventurous element to photography, doubling the occasion for celebration, something traditional cameras could not match, but instead of emphasizing this important difference, Polaroid focused on making its products more technologically sophisticated, thus competing on Kodak's turf and squandering an excellent opportunity to change what photography meant to the masses.

In the case of disc cameras, Kodak did not engage in any meaning-changing activities. The disc camera was a product that reinforced the existing understanding of photography: a simple, fun activity accessible to the masses, which wished to 'preserve memories.' Kodak strove to improve quality of images and reduce the complexity of taking pictures. However, when 35mm cameras, based on an open standard, quickly surpassed the technical standards achieved by the disc, Kodak then shifted its advertising stance to promote a 'different cameras for different needs' concept (Figure 8.1). However, 35mm cameras were already following a strategy of "the same camera for different needs" bridging the functionality of expensive SLR cameras with the user-friendliness of cheaper, point and shoot models, and simultaneously taking advantage of leaps in electronic technology. Moreover, as discussed earlier, Kodak's disc was a completely new medium, which required the institutionalization of completely new processing routines. The 'simplicity' and 'quality' offered by the disc was easily beaten by 35mm cameras, which became the dominant design and an embodiment of what photography should be. Similar dynamics were apparent in the case of digital cameras. While no dominant design had yet emerged, either at the technology - , or at the digital camera level, some changes in the practice of photography were already apparent as discussed at length in the digital case.

From the evidence presented in this thesis, the battles for the creation of meaning varied in intensity across cases. This intensity was highest in the cases where the success of the new technology required major changes in existing infrastructure and meaning systems. For instance, for the roll-film camera to succeed, the meaning of photography had to be transformed from a highly specialized activity to a simple, everyday one and several norms institutionalized regarding who was to take photographs, where and how. In contrast, the radically new disc technology simply reinforced existing meaning and did not require a change in the meaning of photography. Polaroid, on the other hand, offered a significantly different routine for taking pictures, making demands on existing cognitive understandings of what photographic technology was supposed to do. However, the company was not nearly as interested in changing the meaning of photography as it was in competing on existing evaluation criteria of efficiency and technological sophistication. Finally, in the digital imaging case, an intense battle was raging between incumbents and new entrants to change what photography, and photographs, were supposed to be: hard prints or images? For preservation of memories or sharing? With computers, or without? Digital imaging was a fundamental change that nullified the very definition of photography found in the dictionary: the formation of an image on a chemically coated surface. It thus made the most demands on existing cognitive understandings of photography as well as on the existing infrastructure that had evolved around traditional photography.

Lock-in Networks

A rather interesting finding of this research relates to the creation of what might be called ‘lock-in’ networks. I have already discussed how networks comprising agents as well as artifacts or institutions form around nascent technologies in the process of evolution. I will now discuss how, when the focal actor is able to position its design in a way that a relationship of dependence is established between itself and stakeholders, this network may become a 'lock-in' network. While the construction of meaning and enrolment of stakeholders is critical to forming a network, dependency is achieved through ‘mediation.’ Mediation denotes the creation of an obligatory passage point in the industry, or conversion of a proprietary design into a truly critical resource. Indeed, a competitive advantage based on technology can only be sustained for as long as the proprietary design or technology remains a critical resource in the industry. Since the critical value of the design is directly attributable to the network of regular structures supporting it, this network must be controlled and perpetuated in the face of a maturing market and increasing ability to substitute of products based on the new technology.

Technology management literature shows that firms usually go for either controlling or perpetuating a network rather than both. For example, IBM perpetuated its

PC network by following an open systems architecture strategy. While this allowed IBM PCs to become the dominant design, IBM was not able to control this network, and after a few years, its market was taken away by cheap clones. Indeed, IBM reverted to a proprietary bus architecture for its PS/2 line, thus opting for a control strategy (Moore, 1995). On the other hand, empirical evidence has shown a strategy of controlling a network by guarding its boundaries to be sub-optimal too. Polaroid followed this strategy, profiting tremendously only to start losing control of the network as the market adopted another design. Latour (1987) argues that a sustainable competitive advantage based on technology is only possible when the network is perpetuated as well as controlled. Perpetuation of a network involves enrolling more stakeholders to support the design, and controlling it ensures that it does not collapse. Latour (1987) has argued that perpetuation and control is possible through the establishment of obligatory passage points. That is, the firm positions its most valuable resource, proprietary technology, between actors' interests and their alternatives, thus converting a chain of associations into a 'lock-in' network. This is in line with Burt's attempt to conceptualize inter-organizational transactions as a social structure (Burt, 1995). Following Burt, the firm must position its proprietary technology in 'structural holes.' Burt denotes a relationship of nonredundancy between two contacts, as a structural hole. The hole is like a buffer, or the space between transacting parties. Microsoft's strategy provides an excellent example of first enrolling a group of stakeholders and then positioning itself strategically to benefit on a sustained basis. After its license with IBM expired, Microsoft started providing DOS, now called MS-DOS, to other manufacturers too, thus enrolling new members. By licensing its operating systems (first MS-DOS and then Windows), cheaply to original equipment manufacturers, Microsoft created an obligatory passage point (Latour, 1991) for most actors in the industry. Positioned in this way, the technology assumes the position of a mediation device, or something that comes between a user's interests and alternatives. A mediation device is essentially a proprietary technology, which is made an integral part of an industry's architecture.

Following this argument, the sustained success of Kodak can be attributed to its ability to insert the roll film between the user and photography. Any camera that one may wish to use - barring digital cameras - requires a film, a market over which Kodak still has an almost monopolistic control. While Kodak was initially dominant in both camera and film markets, it gradually pulled out of the camera market, concentrating on keeping its hold on the mediation device: film. While there are no ostensible barriers to entry into the film market, Kodak's initial monopolistic control over camera, film and processing has given it an almost insurmountable clout in this industry. In this respect, film functions much like Microsoft's operating system, other than the fact that while Microsoft's product is proprietary, Kodak's is not.

After inserting technologies as mediation devices in the architecture of an industry, firms may choose to encourage the addition of derivative products on top of the design. The more applications or derivative products are added to the network, the more invincible the design becomes. The rapid success of application software by Microsoft is a case in point. It is not important to our analysis that the application software was successful, but what must be realized is the 'factualizing' and embedding influence it had on the operating system that served as the platform or gateway for such applications. Similarly, Microsoft's agreements with banks, utilities, credit card companies, and phone companies for carrying out several activities will have a similar embedding influence on the underlying technology. The introduction of 'software suites' by several software developers also has the same effect of deeply entrenching the platform on which they are based. In much the same manner, the proliferation of camera models has served to entrench the roll film.

The digital imaging revolution has seen Kodak and Sony pursuing the same mediation strategy in a bid to control the evolution of the industry. Kodak is seen pushing hybrid designs; the ease and convenience of digital technology and sharp images, packed in one product. Hybrid solutions preserve its existing chemical-based imaging capabilities. Kodak seeks to build a chain of associations around the Picture CD. The several thousand independent photofinishers represent a natural ally for Kodak since they stand to go out of business with a technology that is entirely digital. Moreover, Kodak is attempting to persuade other stakeholders such as the software, scanner, printer, and camera manufacturing industries. They all represent regularities in the marketplace. These are structures that are considered legitimate and stable.

If Kodak is successful in embedding its CD within this existing system of regularities, the race for the dominant design will be over, or at least the odds facing the next innovator will become substantially high. Moreover, since in this industry the consumer benefits from the market success of the particular design he/she purchases, regardless of the performance, the process would be recursive. The software industry will focus on developing new applications that include new advanced features for manipulating the image, the scanner industry will concentrate on improving their performance given the new constraint, and similarly the printer industry will aim at producing hard copies that are as close to the image produced as possible. These resulting behaviors would reinforce the structure that produces it, and the cycle will go on until broken by the next discontinuity.

On the other hand, Sony appears to be positioning its own proprietary design, the memory stick, as a mediation device. This is the same strategy that Microsoft adopted when it shifted the focus of the PC industry from hardware to software. Sony has announced licensing agreements with several manufacturers around the proprietary memory stick technology. In a clever strategic move, Sony had introduced new externalities, based on its own competence and strength. Instead of choosing a technological format shared by most imaging firms, Sony has striven to make the memory stick compatible across all electronic devices. If successful, cameras could become what PCs are today: Almost generic hardware to run proprietary software. By inserting the memory stick as a mediation device, across several industries, Sony would be building its organizational goals into the institutional system, much like Kodak did earlier in the century and as Meyer and Rowan suggested firms do in their 1977 article. Both the memory stick and the CD have the potential to lock-in the emerging field, leaving their sponsors or proponents in commanding positions. However, whether Kodak or Sony are successful in their attempts depends upon their ability to convince other stakeholders to incorporate their technologies into their products. This, in turn, depends upon whether these products are able to embody the stakeholders' interests.

Mobilization

The lock-in network is in place once a design becomes established as a 'fact.'This means a number of things: that it is reflexively considered the most feasible solution to a critical problem; it isdeeply embedded in regular structures; enjoys the support of several agents who have committed resources to it; provides a platform for several applications or derivative products; and is successfully positioned as a mediation device.. However, as Latour (1987) suggests, the design is not invincible. As argued before, a technology remains a 'fact' for only as long as it is supported by the network. When threatened by outsiders, powerful proponents of the design usually take on the role of spokespersons, thus providing an identity to the network and speaking on behalf of all the actors and structures regarding the capabilities or possibilities of a technology. Rather than presenting all the facts about the technology, the proponent (or one who stands to lose the most) presents simply the 'relevant' facts, thus perpetuating existing evaluation routines (Garud and Rappa, 1994).

Thus, as long as the lock-in network is not threatened there is little need for a spokesperson. The technology is an established fact and facts speak for themselves. However, when the fact is threatened, the focal firm struggles to protect the lock-in network which provides it with its power. Thus, Bill Gates has become the spokesperson for the American consumers or for the members of Microsoft's network, pointing out repeatedly that Microsoft's interests are aligned with the consumers'. Indeed, it is a common strategy in hi-tech industries to hold press conferences with multiple stakeholders present, such as customers, analysts, partners, distributors and acting as their spokesperson (Moore, 1995).

Figure 8.1 illustrates competitive dynamics that follow a technological discontinuity. Several claims compete for widespread acceptance, a process driven by various strategies employed by proponents. As competition among these designs unfolds problematization takes place, whereby proprietary designs are framed as solutions to existing or emerging problems and evaluation criteria employed which favor the particular design. The design is regularized through the creation of linkages with existing, well-recognized technological artifacts, and existing stakeholders are enrolled through the modification of the design in order to embody their interests. At the same time, the design is positioned as a platform for future development in the industry; introduction of derivative products is encouraged and the design connected with new activities. The network thus formed is strengthened by leveraging the design for new uses, integrating it with new activities and enrolling more agents. Finally, whenever the design, and hence the interests that it embodies, are threatened, incumbents strive to protect it by acting as spokespersons for existing and proposed stakeholders, a strategy which may buy them time to develop new competencies.

CONCLUSION

To summarize, I have argued that following a discontinuity, nascent designs cannot be compared on the basis of their inherent technological attributes. Often, such designs do not perform better than existing ones on prevailing evaluation criteria. However, in some cases, proponents are able to maneuver the institutional process through which the market makes sense of the new design, providing social 'reasons' for adopting the new technology. However, in order to become dominant a design needs to embody the interests of a strong network and draw on the stability of existing institutions. Without support from a strong network of stakeholders, and alienated from all stability-providing institutions, a design has little chance of success. Moreover, some technologies that are positioned as obligatory passage points are able to sustain their dominance for longer periods. Finally, once a network is in place, stakeholders resist all pressure from innovations seeking to disintegrate it.

FIGURES TO CHAPTER 8

Figure 8.1: The Journey of a Design: From Claim to Fact

CHAPTER 9: SUMMARY, CONTRIBUTIONS, AND DIRECTIONS FOR FUTURE RESEARCH

This chapter briefly summarizes the research conducted in this thesis, and discusses the various contributions that it stands to make to research and practice in the field of technology management. It also outlines future directions for research in technology evolution and change.

SUMMARY

This study explores four technological shifts within the photographic industry. The four cases were chosen on the basis of their varying outcomes and other differences such as proprietary vs. non-proprietary technology, insider vs. outsider sponsorship, and the 'radicalness' of the change each technology engendered. For instance, while disc cameras represented a smaller, although 'competence-destroying' change, digital represents a paradigmatic shift. Together, the four cases complement each other, and generate a balanced theory of how technologies evolve. The exploratory nature of the research design, integrates the insights provided by theoretical perspectives ranging from institutional theory to path dependency with case study analysis. , Based on archival data, each case both constructed a narrative to investigate the technology, its design, its 'performance', the threat it posed, the institutional changes, which did, or did not, follow it and the outcome. Cases provided the forum for making theoretical, analytical and contextual comparisons, and develop theory. Finally, the four narratives were woven with existing theory to yield new understandings of technology evolution, which developed as well as challenged received wisdom. (Table 9.1 summarizes some of the salient insights drawn from each case)

The study found the popular perception that customers eventually adopted technologies that 'better' met their needs 'to be an over-simplistic and dangerously misleading one, particularly when radically new technologies, that required a different understanding of photography, were involved. For instance, roll-film cameras were desirable only if photography was a popular social activity for the masses. Given that photography was understood by all to be so, roll-film cameras were a 'better' option than dry plate ones. However, when a radical technology is introduced into the market, it is radical only because such understandings and the necessary physical infrastructure to make it appear desirable do not exist. It is then up to the sponsor to structure the field so that the nascent technology which is still only a claim, can be institutionalized or turned into a fact. This feat, however, is rarely possible without the support of a strong network. In order to build such a network, the sponsor or focal firm has to open up the technology sufficiently so that others can embody their interests in it. The less disruptive a technology is, the easier it is for stakeholders to adopt it. In order to make the technology less disruptive, associations and linkages are created with existing structures. "Enrolling" institutions in this manner stabilizes the nascent technology, reducing its disruptiveness and creating positive externalities around it.

The enrolment of stakeholders serves to 'black box' the design. Whereas several possibilities for better designs may exist, since all interests are embodied by the present one, it is not subjected to scrutiny anymore. The 'ferment' ends and an era of incremental change, onesthat serve to further entrench the core technology, treating it as a platform, ensues. How long the design stays dominant depends upon its position in the industry architecture (Christensen, 1997). If it is positioned as an obligatory passage point (Latour, 1987), it is likely to stay dominant for much longer than if it is simply the foremost technological solution to the central problem. For instance, if Sony's memory stick succeeds, it will be positioned much like Microsoft Windows is at the moment, and Kodak's film was for a long time. Any new camera or even any other electronic device will have to deal with the path dependency that the memory stick will introduce in the field, choosing to either become part of the expanding network or try and create a new one. The network collectively guards the dominant design. When it is threatened, the network struggles to protect the lock-in network, which provides it with its power. The firm whose proprietary technology the design protects becomes the spokesperson for the network seeking to gather all the resources necessary to retain the set of practices and their associated understandings that have evolved around the technology.

Table 9.1: A Summary of the Four Narratives and Key Insights

Case	Central Problem (s)	Key Dynamics	Key Insights
Roll Film-Kodak	How did roll film technology, initially rejected by the market, become dominant? How was it able to sustain its dominance for around 100 years?	Eastman Kodak was able to structure a new field around its technology, leading to a fundamental change in the popular understanding of photography (from alchemy to 'Kodaking'). A new social practice was created as part of a process in which Kodak built its economic goals into the norms/ rules of society. Finally, film was positioned as an 'obligatory passage point' within the industry, leading to its sustained dominance over a hundred years.	Roll film was successful not because it met previously unmet needs, but because of a fundamental shift in meaning that Kodak facilitated, albeit in a changing institutional context.
Instant-Polaroid	Instant photography was set to become the dominant design. What led to its demise?	Polaroid's problems were caused by its technology policy. Specifically, its demise was caused by its decisions to 1) keep its technology proprietary, 2) alienating stakeholders by making existing component technologies redundant, and 3) not allowing Kodak to develop a stake in instant photography and thus weakening its own network in face of competition from the 35mm network.	The process of enrolment begins with product design. Designs embody interests of stakeholders and must be recognized as such. The dynamics of technology adoption are different when competition from an open standard is present.
Disc-Kodak	The disc was touted to be the future of photography. In the first two years, it broke all sales records. Why did it fizzle out within the	The disc failed because of Kodak's inability (or unwillingness) to create a strong network around it. In the absence of committed stakeholders, the promised performance	Sponsor's clout is no guarantee of success. Even organizations with enormous clout need others to deliver on their

	next three years?	of the disc could never be realized. Moreover, the technology was kept proprietary at a time when the industry had the option of joining the open 35mm network.	claims. And others are only enrolled if the design is opened to embody their interests.
Digital- Open	The digital revolution in photography, led by Sony, is threatening the age old, extremely profitable business that firms like Kodak have created around traditional film-based photography. Why isn't the 'better' technology winning?	The case illustrates the seemingly chaotic situation when several firms compete to make their designs part of the future practice of photography. Gradually, the availability of digital cameras along with several institutional changes has led to transformation in the existing understanding and practice of photography. The strategies and positions of both incumbents and 'new entrants' have been evolving over the last 20 years, generating strategic responses from both sides, which have come closer over time.	Designs stabilize as they enroll regular structures and embody the interests of other players. Moreover, some technologies that are positioned as obligatory passage points are able to sustain their dominance for longer periods. Finally, once a network is in place, stakeholders resist all pressure from innovations seeking to disintegrate it.

CONTRIBUTIONS TO RESEARCH

This research has generated new insights, by virtue of bringing together several research streams to develop a new understanding of how dominant designs are constructed and competitive advantage attained, altering current understandings of technology strategy and bridging economic/ functional understandings of technological change with social ones. Specifically, this research, its theoretical development and empirical findings has the capacity to contribute to the technology management, institutional theory and path dependency literatures. .

Contributions to Technology Management Literature

The primary contribution of this study to the vast literature on technology evolution and management has been the theoretical process developed to explain causality. Several authors, (e.g., Tushman and Rosenkopf, 1994) have stressed the need for developing causal explanations for technological success. Since an increasing number of studies has pointed towards 'social factors' as a key determinant in the success or failure of technologies, researchers have emphasized the need to study situations where the role of social factors is expected to be significant. This was certainly one consideration in studying the photographic industry. While there have been several studies of large scale projects (Hughes, 1983; Garud, 1989; Law and Callon, 1992) and complicated technologies (such as Rosenkopf's study of flight simulators, 1992) to explore how and why particular technologies emerge as dominant, the present study differs from these in an important respect. Photography is a popular pastime, as opposed to a highly specialized practice, and the market consists of 'atomized' consumers rather than scientists or researchers. Social/institutional changes in demographics, economy, culture, and important social and technological developments thus play a far more important role in this case than in technological 'projects.' As expected, results of the study fully reflected the profound social influences on technological evolution.

As discussed above, the causal explanation developed in this study challenged several existing beliefs about technology evolution. For instance, in contrast to determinist arguments attributing superiority to particular designs, it was found that superiority is an acquired trait. The study lends further support to Christensen's (1997) finding that customer expectations were vague and extremely difficult to determine with respect to radically new technologies. Thus, the rather common understanding that dominant designs are the 'best' possible combination of elements from the various competing designs (Utterback, 1994) is seriously challenged. Instead, it is argued that what is 'best' is defined through a process where the technology is socially defined. What is digital photography supposed to be? What is its relation to conventional photography, or how is it different from conventional photography? What is its relation to other technologies that we use: computers, printers, cell phones, email? Who is supposed to have digital cameras: professionals or laypeople? Is it necessary to have hard prints? Is quality really that important to people? All these are social questions, not technological ones.

Moreover, while discontinuities, defined as changes in key components, technology or architecture of a particular product class - cars, computers, cameras - constantly occur, not all of these are necessarily destructive to the existing competencies of players. For instance, the introduction of auto-focus lenses or single-lens reflex technology did not destroy incumbents, but simply posed another technological challenge for them. On the other hand, the introduction of the proprietary roll-film technology or Instant technology constituted a discontinuity, which could 'potentially' be destructive. It is important to note that discontinuities, even if they are 'competence-destroying' (Tushman and Anderson, 1990), are only a threat, which may or may not result in the destruction of existing capabilities. For instance, while disc technology represented a crucial technological change in photographic technology, it failed to destroy existing capabilities. Similarly, Polaroid did not lead to a new dominant design, even though it came quite close.

I have argued that competence-destroying discontinuities represent claims made by proponents of the new technology. Whether they result in the constitution of a new institutional field or not depends upon the proponent's ability to convert these claims into facts, where 'fact' means that the technology is the best and most feasible method of carrying out a particular activity. This process of factualization involves constructing a new meaning around the central activity and enrolling stakeholder support both for this new understanding and the technology that embodies it. For instance, Kodak was able to factualize the roll film by changing the meaning of photography so that roll film technology became the obvious solution to the new photographic market. Similarly, proponents of digital technology are engaged in the process of institutionalizing a new understanding of photography around their technology. Finally, using 'lock-in' strategies, players may insert their proprietary technology into the emerging architecture of the industry so that it becomes an obligatory passage point for all users.

Finally, in explaining how the questions that inevitably arose after a discontinuity, I found the structuration perspective advanced by Giddens (1984) quite helpful. While previous studies (Orlikowski, 1992; Garud and Rappa, 1994) have utilized insights offered by this perspective, none of them have pointed to the role of existing institutions or regular structures in determining the success of new technologies. This study took the insights developed in previous studies further by providing a rich description of how several different meanings were constructed around nascent technologies in the wake of ambiguous consumer expectations. This battle over meaning was conducted through three primary channels: advertising and other corporate communication; enrolment of stakeholders; and association with or incorporation of existing institutions. The study also leads us to believe that firm strategies as well as broader institutional changes are far more important in influencing the evolutionary path followed by technologies than previously believed.

Contributions to Institutional Theory

Being a theory of inertia, Institutional theory has traditionally faced a problem explaining change. While recently some studies (e.g., Hoffman 1999) have sought to explain how change comes about in institutionalized settings, a causal explanation is still lacking. Thus, Hoffman admitted in his 1999 study that while he had connected the occurrence of issues to the emergence of new institutional fields, his research "could not prove a causal connection between the events detected and the institutional change that followed." (1999: 367) This study goes some way in explaining change within the institutional context by highlighting the role of organizational agency, as well as that of existing institutions in facilitating change along particular trajectories.

The problem is simple. If everything in an organizational field is institutionalized, where does the impetus for change come from? Meyer and Rowan argued that change agents had to be major institutional entrepreneurs (1977). Or, as DiMaggio and Powell (1983) as well as Hoffman (1999) suggested, change could be externally motivated. Two key motivations for change were found in this study. The first was innovation, as in the case of roll film camera and the second was invention. In the first case, Eastman improved an existing technology to fit the needs of an existing market. Upon failure, he proceeded to build a new field around the innovation. Disc camera falls under the same category. Like roll film, it was introduced by an incumbent, and constituted a strategic move on Kodak's part to exert control over all facets of industry. The difference was that while roll film evolved along with a new institutional field, disc was an attempt to strengthen Kodak's dwindling position in the existing field.

The second type of change was through technological invention generated outside the field by Polaroid. As emphasized by institutional theorists, external players, who do not have existing competencies to defend in a particular industry, most often introduce inventions. Thus, it did not matter to Polaroid if traditional photography was threatened by Instant technology. Similarly, it does not matter to Sony if the entire field that exists around roll film technology is destroyed along with related capabilities that have been developed around several decades.

This study shows that what keeps a particular technology in place is the meaning system and related practices that evolve gradually around it. A technological change is disruptive only to the extent that it challenges this social structure. From such a perspective, Kodak's decision to launch the disc camera does not appear problematic. The disc camera reinforced, rather than challenged, the existing understanding of photography. However, from the processor's perspective, the disc challenged the practices and routines that had been established around photo processing in addition to the financial investment attached with automated disc processing technology. This implies that had the disc embodied the interests and routines of stakeholders, it could have possibly prevented several stakeholders from defecting to the open 35mm standard, which quickly embodied the interests of the industry. This leads to another important implication. While strong institutional players seem to be in a better position to bring about change, in the case of radically new technologies, it is difficult for them to de-institutionalize practices that they themselves helped institutionalize. This puts them on equal footing with external agents, who usually lack any clout in the affected industry. Note that this is in conflict with Meyer and Rowan's (1977) argument that efforts to change institutional environments can succeed only if they come from powerful organizations, who are in a position to force their immediate relational networks to adapt to their practices.

So far I have discussed the motivations for change. However, there is another important question: If technologies 'co-evolve' with social institutions, as I have suggested earlier, how is technological change possible at all? After all, the market is able to make sense of a particular technology only given the institutions that co-evolved with the technology, for example, the norm of taking pictures at certain social occasions co-evolved with the roll-film camera. A critical insight that emerged from the data seemed to resolve this problem. New technologies, which eventually became successful, drew on the regularity offered by existing institutions. As previously discussed, the 'stability spill-over' effect of existing institutions regularized practices surrounding the nascent technology, by making a disruptive technology less disruptive. However, broader social changes, which are usually partly responsible for the sudden interest in a particular technology in the first place, firm strategies, and technological advances lead to the emergence of new institutions, which co-exist with older ones, in harmony or conflict. This co-existence can continue until the older institutions are challenged by some other development. For example, by incorporating an established technology, the floppy disc, the Sony MAVICA raced to dominance within the nascent digital camera market, but the floppy has since been replaced by the memory stick by Sony to link all electronics. Just as the floppy made the digital camera technology less disruptive, the memory stick is made less disruptive by its association with several everyday electronic products such as PCs. The situation is analogous to a relay race in which technology represents the baton that is passed from the old institutions to the new ones. The passing of the baton does not represent the death of old institutions. In fact, they play an equally important role in the eventual success of radically new technologies; a case in point is the failure of the ultra-innovative SX-70, which did not draw on any established technologies to lessen the disruption, or ease the transition.

Finally, as discussed in the previous chapter, I found only partial support for Hoffman's (1999) conclusion that institutional fields grow around issues and not technologies. When discursive struggles are settled, usually the interests and beliefs of a particular institutional field come to be embodied in a technology, rather than an issue. Thus, while it is true to say that issues shape fields, it is equally true that it is only in conjunction with technological developments that issues are able to do that. Similarly, fields are held together by the consensus that emerges out of discursive struggles over issues and which is usually embodied by a technology.

Contribution to Path Dependency

Finally, I have argued that while the path dependency argument of increasing returns to adoption appears conceptually sound, the four case studies point that the 'random events' explanation as well as the implicit assumption that bandwagon effects will always follow when initial acceptance is somehow generatedhas several shortcomings. . According to path dependency theorists, initial acceptance, due to any reason, should generate bandwagon effects, leading to the eventual prevalence of an 'inferior' technology. In the case of the disc camera, within 5 years, 25 million cameras were sold. The first year of its sales, the format captured 30% of the market. Why were bandwagon effects not witnessed? What prevented increasing returns to adoption from kicking in? Again, this study offers some insights that may be helpful in explaining these apparently contradictory findings. The analysis here implies that the development of bandwagon effects is not as random a process as path dependency theorists imply. While it is difficult, theoretically or empirically, to rule out the importance of random events, the present study indicates that some designs have a greater probability of becoming centers of band wagon effects than others. For instance, designs, which are open to the embodiment of existing beliefs and interests would stand a greater chance of kick starting bandwagons. Thus, while the disc camera had Kodak's enormous clout behind it, it could not deliver on the claims it had made because of its abandonment of strategic stakeholders, which though individually weak, were potent enough collectively to doom the technology. On the other hand, the 35mm camera was a standard open to modifications and innovations. Thus whereas 35mm technology *allowed* the development of bandwagon effects, the exclusionary policy behind the disc *prevented* it. Similarly, the SX-70 prevented the co-option of the technology by stakeholders, thus remaining an isolated technology, unable to become a platform upon which future developments could take place.

Similarly, the assumption that some industries exhibit positive network externalities guiding technological evolution in particular directions while others do not, appeared fragile. Indeed, technology was found moving forward through the creation of new externalities such as Sony's strategies to link various industries under its umbrella together. Thus a key influence on the particular direction taken by technology's evolution is Sony's various businesses.

CONTRIBUTIONS TO MANAGERIAL DECISION-MAKING

Apart from theoretical contributions, the present study provides several insights that can potentially help managers make more informed decisions during eras of ferment. The most important insight concerns the basis from which one chooses a technology. I argued earlier that radically new technologies must not be judged on the basis of existing evaluation criteria or understood through existing institutionalized understandings of the activity that is facilitated by the technology. These criteria have evolved around the incumbent technology and account for its dominance. However, many managers are commonly faced with the difficult problem of investing in one of several competing technologies at various levels. At the first level, for instance, managers in the photographic industry have to decide whether or not to invest in digital imaging technology. And if they decide to invest, how strongly do they wish to commit to this new technology as opposed to traditional technology? At the second level, if they decide to invest in digital, they must make several other decisions regarding the choice of technologies. For instance what is the memory storage technology to be? Compactflash, memory-stick or Smart media cards? What type of sensor are the cameras going to employ? CCD or CMOS?

Which of these technologies are likely to be more successful? The functionality of these technologies can be measured utilizing several criteria, none of which is more suitable than the other. For instance, memory storage devices can be measured on familiarity, storage capacity or universality. Similarly, the success of digital cameras is far from certain; after all in the last 20 years they have only been able to acquire less than 4% share in the camera market. Understandably, the decisions are fraught with risk and subject to a host of contingencies. However, the theory developed in this study does have some important implications, which may help managers make more informed decisions.

Rather than any functional criterion, technologies should be measured on whether they embody the interests of stakeholders, incorporate existing institutions and make sense socially. A technology, which embodies the interests of several stakeholders, should have a greater likelihood of succeeding than a technology, which performs better on the existing evaluation criterion (at the beginning of the era of ferment). And if path dependency arguments hold, before long, the former technology should become better at whatever evaluation criteria the market employs to measure performance than the latter. The advantages associated with the incorporation of existing institutions or association with them has also been discussed already. The design benefits from regularity spill-over effects, as opposed to a new, functionally better design which does not. Finally, the technology must make sense socially. This means that social norms and cognitive beliefs must be encouraged which help consumers make sense of the technology in everyday life. For instance, Kodak encouraged the institutionalization of several norms surrounding photographic practices in the early part of the century, many of which still prevail. Similarly, proponents of digital are battling to establish norms around the use of digital images.

The theory of 'lock-in' networks rejects the implication of the frequently used ecology metaphor that technologies mate by themselves producing better offspring that are more adapted to current resource conditions. Instead, it argues that agency is at the heart of technological evolution. It is the primary force underlying the success of one design rather than another. As Latour remarks, on its own, a design is like a rugby ball, sitting on the ground, waiting to be picked up and made part of a play. Watching a technology rise to dominance, without looking at the underlying dynamics is like watching a rugby game on TV where invisible players are playing with a phosphorescent ball. You capture all the movements of the ball, but miss the underlying skill, coordination and strategies (Latour, 1987).

While the theory presented in this study probably lends itself most readily to hi-tech industries that contain more interdependencies, and where the pace of evolution and convergence is quick, the argument applies to "low-tech" fields as well. If network externalities do not already exist in a field, they may be induced strategically into the development of product classes. The example of the photographic industry illustrates how new externalities may be introduced into an industry. The implications of this study should also be of great interest to managers of both small and large firms. The era of ferment offers unprecedented opportunities to innovators who may start out resource-poor but may still be able to create a 'lock-in' network. The membership in the network is completely voluntary, arising first from an alignment of interests, and then from increasing strength of the design. Thus, 'lock-in' networks should be differentiated from anti-competitive networks where firms bundle technologies to build on an existing advantage. For example, in the early years of the roll-film camera, Kodak included developing costs in the price of the film whereby the camera had to be sent to Kodak where the film was developed, and a new one loaded. In this way Kodak had a virtual lock on the market. This practice was deemed anti-competitive however, and the practice was broken through regulation in the 1950s. Similarly, Microsoft's efforts to bundle their browser with the operating system must not be confused with the development of a lock-in network. In forming 'lock-in' networks, firms essentially encourage the production of derivative products and applications in order to entrench the existing design more deeply, rather than to lock-in profits on derivative products.

A major contribution of this research relates to the issue of selection of designs. While the scope of this study is limited to competitive strategy, it does not mean that organizations can bank only on competitive strategy. The development of sustained product development capacities (Dougherty and Hardy, 1996), dynamic capabilities (Teece and Pisano, 1994), and the management of innovation streams (Tushman, Anderson and O'Reilly, 1997) is equally important to success in the market. Organizations cannot transcend technological discontinuities without having the in-house capabilities required to be flexible, innovative and market-oriented. However, extremely creative organizations like Kodak, Apple and Xerox seem to face real difficulties when it comes to gaining a foothold in the market. We must recognize that while a lock-in framework provides strategic opportunities to such organizations, especially in times of discontinuities, it is only a partial explanation of how certain designs may become successful.

To summarize, this study contributes to existing research on the evolution of dominant designs in several ways. For example, in this study I have constructed a framework, which removes some of the mist in the "oversocialized" understanding of technology evolution, which is prevalent today, and added managerial agency to the debate. I have also highlighted the significance of networks in relation to technology evolution and design selection and outlined a strategic approach to influencing this process through the creation and management of lock-in networks. Moreover, while most studies deem discontinuities as either competence destroying or competence enhancing, I have raised the possibility that organizations may be able to modify the competence destroying or enhancing aspects of a discontinuity. Through the creation of lock-in networks, organizations may be able to strategically utilize the players normally considered powerless and peripheral in all industries such as independent photofinishers in the photographic industry. Finally, this study was a step towards bridging the technology and competitive strategy literatures while developing a comprehensive tool for managers to enhance the success probability of their innovations.

DIRECTIONS FOR FUTURE RESEARCH

The technology evolution theory presented here is at an early conceptual stage. Future researchers should attempt to extend it to ensure its comprehensiveness and explore whether other conditions should be added to the model or whether research or management practice yields other factors that regularly influence the selection of dominant designs. For example, are there more specific industry scenarios conditioning the importance of factors influencing the likelihood of selection? Are there important technology factors either forward or backward in the chain of associations that have not been identified here? Should the disruptive effect of radically new technologies be measured in terms of their effect on existing capabilities, as seems to be the prevailing custom? Or should their 'radicalness' be gauged from the change they engender in the social context?

Towards a New Classification of Dominant Designs

While all the research surveyed in Chapter 1 has contributed to our understanding of technological evolution in various industries, its determinants and consequences, it has also led to confusion over its fundamental definition, unit of analysis, causal mechanisms, boundary conditions, and linkages to organizational outcomes (Tushman and Murmann, 1998: 231). It seems that an important cause of these problems is the focus on products rather than on the practice around which an industry is formed. Most research on dominant designs tends to focus on the product level: VCRs, PCs, airplanes, watches. Various explanations have been put forward for why one product design replaces the other including strategic action on part of the new design's proponent, technological imperative, network externalities, market clout and complex 'socio-political' processes (Barnett 1990; Cusumano, Mylonadis and Rosenbloom, 1997; Utterback, 1994; Tushman and Rosenkopf, 1992; McGrath, MacMillan and Tushman, 1992). Taking this research stream forward, Tushman and Murmann (1998) point out that in order to really understand the evolution of designs and how change occurs it is critical to understand the locus of change. They argue that dominant designs apply most fundamentally to a product's subsystems and linking mechanisms. When a technological advance is made in a subsystem such are landing gears in airplanes, it soon becomes an industry standard. Thus, industries evolve through advancements at the subsystem level. In this case, the product , airplanes, is slowly transformed through changes in its components. Thus the evolution of the industry may be studied in terms of the dominant designs that emerged at the system, subsystem, and the basic component level of analysis. According to Tushman and Murmann, dominant designs appear at the product level only when subsystems and linking mechanisms are in eras of incremental change (1998).

Despite Tushman and Murmann's (1998) deconstruction of the product, their theoretical work still remains tied to the product level. By labeling products as systems, their theory leaves little room for the larger system in which the product is used or created. As a result, explaining any changes in the abovecontext and beyond the product level becomes problematic. A look at the photographic industry illustrates that sometimes industries undergo transformations that change the relationship between systems, subsystems and components; positions are interchanged and new levels are created. For example, Tushman and Rosenkopf (1992) have identified three major discontinuities in the photographic industry: wet collodion process, dry gelatin process, and roll film. The next discontinuity in the photographic industry is digital imaging (Utterback 1994). Should digital imaging be treated as just another competence-destroying technological discontinuity at the 'system' level? After all, the previous discontinuities were all within the chemical-based imaging paradigm, whereas digital imaging represents a fundamentally different way of capturing images. As long as we were in the chemical-based imaging era, we counted dominant designs within that realm, taking chemical-based imaging as a 'fact'. Upon entering the digital imaging period, however, we can at once see that the present discontinuity is one level above the previous discontinuities. Indeed, it nullifies the definition of photography provided by most dictionarie: the formation of an image when light acts on a chemically sensitized surface.

Understanding designs with reference to activities removes these ambiguities and leaves room for dynamic change in the industry, even completely revolutionary changes such as digital imaging. The evolutionary dynamics of industries often go beyond a single product and require a more pluralistic framework. A consideration of the camera, film or lens industry in isolation from each other or from societal institutions in general, can only generate narrow conclusions.

An emphasis on products automatically leads to attribution of most technological changes to technical imperatives, producing an "undersocialized" (Granovetter, 1985) theory of dominant design evolution. Perhaps, in order to resolve the confusion around the concept of dominant designs we switch our attention to the activity around which industries emerge. One way of understanding technological evolution based on 'practice' an activity becomes a practice when carried out through a particular, socially accepted routine. For example, photography is an activity, but the particular manner in which it is widely conducted constitutes a practice. Conversely, a product could be a classification system of dominant designs based on "technology context (TC) levels". For instance, the evolution of the photographic industry may be viewed in terms of 4 TC levels (Figure 9.1). The first level, which sets the context for the next levels, is chemical-based imaging. The second level represents the technique, which is considered the best way to perform chemical-based imaging: roll-film system. The third level includes designs of cameras, lenses, films and paper, all the implements of the roll-film system. Finally, the fourth level comprises the entirely derivative and complementary, photofinishing business. Viewing the evolution of dominant designs in terms of the focal activity would allow us to assess the role of institutional processes in the success or failure of designs. The relation between users and designs is a critical influence on the evolution process, albeit one that has often been neglected in favor of technological explanations. It is central to an understanding of why some designs become more institutionalized than others, and why certain technologies even when 'superior' fail to displace existing designs.

Classifying dominant designs in terms of TC levels would lead to new and important observations about the evolution and sustainability of designs. For example, we would expect designs or techniques at the center of the concentric hierarchy (chemical-based imaging) to provide the context in which users would understand the focal activity, and in which all higher-level innovations would occur. By going higher in TC levels, designs would become increasingly peripheral to the central activity and change more frequent and easier to bring about. This is speculation and more research needs to be done before the usefulness of such a hierarchy can be established. For instance, perhaps we could consider classifying technological changes in terms of the change in social meaning of an activity that they require to succeed? Or simply add another layer of social meaning to the four TC levels?

Figure 9.1 About Here

Usefulness of the Industry Concept

When management theorists study technological evolution their unit of analysis is almost always a particular "industry" usually measured through SIC codes (Abernathy and Utterback, 1978; Tushman and Anderson, 1986; Anderson and Tushman, 1990; Van de Ven and Garud, 1994; Rosenkopf and Tushman, 1994). Typically, they trace the evolution of a particular product through successive technology regimes and draw implications for organizations. Notable examples include studies on the evolution of VCRs (Cusumano, Mylonadis and Rosenbloom, 1988), watches (Glasmeier, 1991), typewriters (Utterback, 1994), aerospace (Tushman and Murmann, 1998), minicomputers, cement and airlines (Tushman and Anderson, 1986). Implicit in all these studies is the notion that industries are defined by products. Regardless of the fact that in many of these examples, the product itself was drastically transformed. Take, for example, which evolved into wordprocessors and then subsumed by computers, Thepopular conception of the activity which that particular product facilitated or made possible was changed qualitatively; theorists insist on viewing evolution and transformation of a particular set of activities through an "industry" lens. Imposing a mythical frame on reality, however well institutionalized the frame may be, produces theories that are more convenient than robust.

A look at the photographic "industry" reveals some serious shortcomings of this concept. As the 'industry' evolved, what was it *really* that was evolving? The camera business adapted to changes in the surface on which the image was created; the copper-plate business went out with the advent of glass plates; the glass-plate business went out with roll-films; the roll-film business is severely threatened by digital imaging. Look at he lens manufacturing business, the paper manufacturing business and the photofinishing business in which several thousand photofinishers stand to go out of business if digital imaging succeeds. Is there such a thing as the photographic "industry?" Who does it include? Can SIC codes even come close to giving us a true picture of the photographic industry? Table 9.2 shows the SIC codes across which this industry is spread.

Table 9.2: A Partial List of SIC codes covering the Photographic Industry

Code	Business
3663	Photo transmission equipment-mfg.
7384	Photo finishing laboratories, except for the motion picture industry
3641	Photoflash and photoflood lamp bulbs and tubes
3861	Photoflash equipment, except lamp bulbs-mfg.
2675	Photograph folders, mats and mounts-mfpm-mfg.
2499	Photographic frames, wood or metal-mfg.
4822	Photograph transmission services

7221	Photographers, portrait; still or video.
5043	Photographic cameras, projectors, equipment and supplies – wholesale
7384	Photographic labs
3827	Photographic lenses
7335	Photographic studios, commercial.
7221	Photographic studios, portrait.
5946	Photographic supply stores
3081	Photographic sheets, film and plastics
3229	Photomask blanks
3826	Photometers, except photographic exposure meters

I contend that what is evolving is not the "industry" but the practice of photography. From an extremely complicated process, which was likened to alchemy by contemporary society in 1839, it evolved into a household practice accessible even to children. Cameras evolved from status symbols to an everyday "fun" device. Now the advent of digital technology promises to transform this practice drastically yet again. Despite its own changing forms, the practice of photography represents the only point of reference in this process of evolution that may be reasonably used for historical studies. Different technologies and organizations have attached and detached themselves with this practice over time, and will continue to do so. In this sense the concept of an "industry" is rather like a balance sheet which only describes the state of a company at a particular instance in time. It is rooted in products and lacks dynamism. If we are to produce better and more robust research, it is imperative that we come up with a more dynamic concept that is rooted in the practice rather than a product, which may be completely eliminated at some stage (like 35mm films may in case of widespread acceptance of digital cameras).

Challenging the concept of industry has enormous implications for strategy-making in general, and technology strategy in particular. It requires managers to re-draw their strategic maps eliminating the mythical industry boundaries.). While the concept of an industry may have been functional when work was not so highly specialized, and organizations tended to be mostly vertically integrated, it is obsolete now and must be discarded in favor of a superior and more robust concept regardless of what the SEC classification suggests.

These are just a few directions, which future research could take. There are of course, countless others,. As I claimed at the outset, the objective of this study was not to prove or disprove anything, but simply to propose a useful, new way of understanding technological evolution, which could stand as a model. The interpretive perspective developed here has yielded several new insights and led to many important implications, the validity of which can only be confirmed by further research and use in practice.

FIGURES TO CHAPTER 9

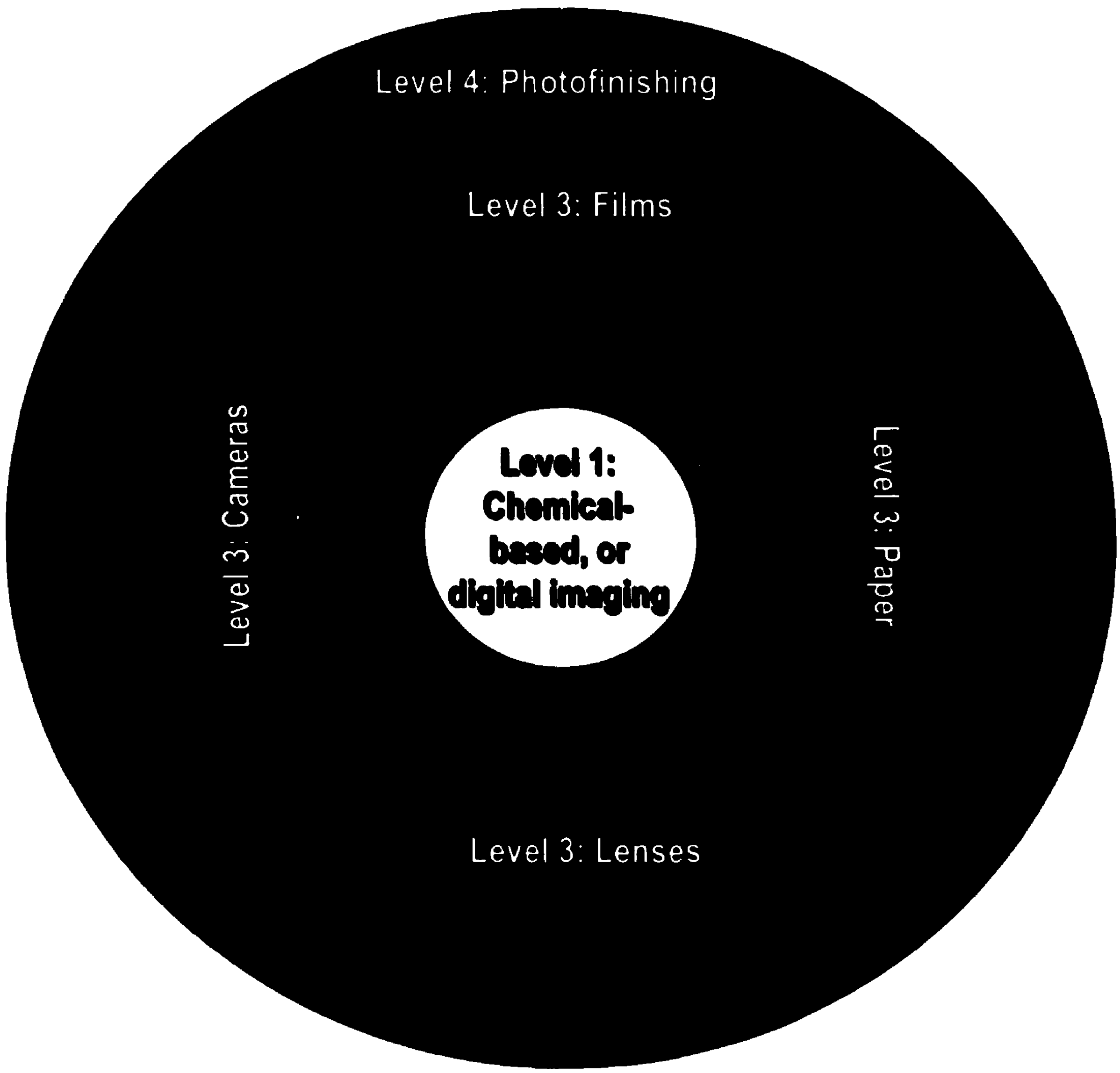

Figure 9.1: Technology Context Levels in the Photographic Industry

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Scribner's
The Photo-American
The Women's Home Companion

Technical/ Specialized Journals

Advertising Age
American Amateur Photographer
Better Photos (Sears, Roebuck & Co.)
British Journal of Photography
Camera
Camera and Darkroom
Camera Notes
Camerart
Cycle and Camera
Eastman Kodak Trade Circular
History of photography
Journal of the Camera Club (New York)
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Databases Consulted

Corptech Database

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Lexis-Nexis

Standard & Poors' Online Database

APPENDIX 1: INFORMANTS

Some of the Industry Informants/Experts who were interviewed[63]

Name of Informant	Designation	Company
Andrew Mougis	Senior Vice President	Electronics Division, Sony Corporation USA.
Michael E. Foss	General Manager, Consumer Digitization and V.P. Consumer Imaging.	Eastman Kodak, Rochester, NY.
Jon Sienkewicz	Vice President, Consumer Products	Minolta Corporation, USA.
Jeff Vanscoyk	National Sales Manager, Digital Imaging Products	Minolta Corporation, USA.
Tim Berry	General Manager, Marketing	Fujifilm Co. Canada.
John Kelly	Marketing Manager, Digital Imaging	Fujifilm Co. Canada.
Joseph Runde	Marketing Manager	Eastman Kodak, Rochester, NY.
Michael Berger	Director Sales, Consumer Products	Polaroid Corporation, Cambridge, MA.
Darin Pepple	Product Manager	Fujifilm Co., Rochester, NY.
Michael McNamara	Editor, Technology Section	Popular Photography Magazine, New York, N.Y.
Bill Smith	CEO (Also President of Digital Imaging Association)	Boston Imaging Corporation, Boston, MA.
Chuck Davenport	Consultant; Was Director Market Analysis for PMA	Lyra Consulting, Massachusetts.
Ursula Kobel	Partner, and Vice President	Image Tech, Montreal.
Michel Nadeau	Vice President Marketing	Royal Photo Corporation, Montreal.
Roland Lebel	General Manager	CORLAB, Montreal.
Pierre Denault	CEO and owner	Fliptech, Montreal.

[63] While I had chats with several other people in the industry, only those who were formally interviewed are listed here.

APPENDIX 2: POLAROID'S SUCCESS

THE INSTITUTIONAL CONTEXT IN WHICH POLAROID ARRIVED

Without understanding the social dynamics surrounding the technology, it is difficult to explain the initial success of Polaroid. In the following paragraphs, I focus on some of the more important changes coming about in Polaroid's environment, specifically, the steep increase in the number of people traveling, the popularity of print media, the reconstruction and celebration of the family unit after the WWII along with a rise in the number of babies born, and a rapidly evolving culture of "ready-made," "instant" foods, clothes and gadgetry. The rising popularity of instant photography was intimately linked with these changes, as I discuss below.

Constructing Families through Images

While during WWII, the subject of popular photography was mostly the war (although magazines like *Picture Post* also existed concerning themselves with the 'home front,' with public life and communal responsibility as well as with military campaigns), in the postwar period, just as in the years following the WWI, a reconstructed economy was based on domestic consumption and the domestic ideal. This required, in particular, women's return to the home to become the pivot of family life, relinquishing their public presence in the workplace and building the ideal of a private sphere where political forces were banished. Family life marked with birthdays, weddings and other events was celebrated whole-heartedly by a generation weary of the ravages of war. Twentieth-century family photography, with its resolute insistence on the creation of happy memories, determinedly reflected this mood, in which politics and world affairs, even the most disruptive, were pushed to the background of public consciousness (Taylor, 1994: 141).

The image of the child became the central icon of family life. By the 1930s the two or three child family was the norm, which meant that individual attention could be given to each child and there was more time for birthday celebrations, Christmas trees and the snapshots which accompany these ceremonies. The domestic camera was confirmed as a ritualized element in joint celebrations. As well as the visible markers for home-centered values, children signified the aspirational optimism of a century dominated by an increasingly prosperous working and lower-middle classes, whose horizons seemed to be ever widening. The modest pictures of the period between the wards give off a sense of hope, a belief in progress and in the possibility of a comfortable life for all (Holland 1992).

These family photos did not, however, stay only in family albums. Indeed, the increasingly consumption-oriented culture led to the appearance of home-based daily life in *commercial* imagery. The expansion of packaged foods and branded goods brought new outlets for visual images, which showed what a happy family *should* be like. Commercial photographers studied how to create ever more convincing pictures of appetizing food consumed by ecstatic and grateful youngsters and of well-groomed mothers delighting in their new technological kitchens. Such images, perfect for advertisements and promotional design, were routinely delivered to the breakfast table on corn flakes packages and baby food jars, and greeted shoppers with their serried ranks on the shelves of early supermarkets. The 1960s burst into commercial color as the burgeoning products for domestic use were promoted by advertising-based supplements to the Sunday papers and an expanding range of consumer magazines, which drew on the new, high-quality color printing techniques. The lush photography on their feature pages came to cover every aspect of domestic life – from Home and Garden to Mother and Baby (Holland, 1992). Snapshots taken of the family imitated the happy families on TV commercials and in magazine ads for butter or margarine now. Life, it seemed, was imitating art.

It is no surprise that in a large majority of family photos from that period, we find well-dressed people, posing self-consciously, often with children (often in their best clothes) in tow. There are hardly any photos of sobbing children or people doing their daily routines (unless we look into artistic/ non-family photos). We are much more likely to find photos of appropriately dressed couples sitting in front lawns or an immaculate looking housewife holding her smiling baby, than we are to find photos of the wife peeling potatoes or scrubbing the floor. Such 'happy memories' were treasured less for their quality than for their *context* and for the part they play in confirming and challenging the identity and history of their users (Holland 1997: 107). Consumers of photos brought to the images a wealth of surrounding knowledge. Indeed, these private pictures were part of the complex network of memories and meanings with which they made sense of their daily lives.

Commercial imagery of family life was instrumental in changing the use of cameras and photography in everyday life. While most users, along with photography-related companies still believed or at least insisted that photography was driven by a clear cut need to preserve memories, it was much more than that. Photography, in social life, had become a source of affirmation for happiness. Even the most problem-ridden families had nothing but happy memories in print! Cameramen were present at every 'important' social occasion, but were implicitly expected to capture only happy moments. Social occasions were becoming an opportunity to 'create' happy memories, which could be preserved through photography. As I discuss in the following paragraphs, such a tendency was also reflected in other facets of society, such as the ever-growing tourist business.

From Travel to Tourism

An important social transformation that occurred around the time that instant photography was introduced to the world was the conversion of travel into tourism. It is important to realize the mutually recursive relationship between popular photography and tourism in order to fully grasp the social nature of photography. The evolution of tourism as a social institution was reinforced by the availability of cameras, and, in turn, influenced the evolution of photography. Taking cameras along for vacations is a norm, but the motivation behind it has changed over the years, from one centered around exploration and curiosity to a ritualistic one which is best captured in the popular phrase, "been there, done that." This transformation has occurred over a period longer than a century, but more noticeably in the last five decades.

By the 1950s, increasing prosperity, together with the introduction of package tours and the establishment of an energetic tourist industry, meant that overseas holidays had gradually become the norm. Boorstin (1964) has stressed the need to distinguish this 'tourism' from 'travel' in the actual sense of the word. Indeed, one of the most ancient motives for travel, when men had any choice about it, was to see the unfamiliar. Boorstin argues that man's incurable desire to go someplace else is a testimony of his incurable optimism and insatiable curiosity. We always expect things to be different over there. Great stirrings of the mind have frequently followed great ages of travel, argues Boostin. "Throughout history by going to far places and seeing strange sights men have prodded their imagination."

In the 1950s, more Americans than ever before traveled outside their country. In 1854 about 30,000 Americans went abroad; a century later in 1954 almost a million American citizens left the US for foreign lands other than Canada or Mexico. After allowing for the increase of population, there was about 5 times more foreign travel by Americans in this period. However, this 'travel' was quite different from that undertaken a few decades ago. Boorstin suggests that all this travel does not really made people more cosmopolitan or culturally sensitive. This is not because Americans are now more obtuse or uneducable than they used to be. Rather, the travel experience itself has been transformed. Many Americans now traveled but few were travelers in the old sense of the word. In the past, traveling was uncomfortable, difficult and expensive. The middle-class American did not go for 'fun.' The scarcity of postal facilities and the lack of newspapers gave an added incentive to travel. At the same time, the hardships of a virtually road-less landscape restricted the foreign journey to those with a serious or at least earnestly frivolous purpose, who were willing to risk robbers, cut-throats, and disease, and to find their own way through trackless heath, vast swamps, and mud that came up to the carriage axles.

Photography, together with transportation and communication technologies, facilitated the decline of the traveler and the rise of the tourist. The word tourist was coined sometime in early nineteenth century – at first it was hyphenated as in tour-ist –

the American dictionary now defines a tourist as a "person who makes a pleasure trip." As opposed to the traveler, who was working at something, the tourist was a pleasure-seeker. The traveler was active; he went strenuously in search of people, of adventure, of experience. The tourist is passive; he expects interesting things to happen to him. He goes 'sight-seeing' (first recorded usage of this word was in 1847). He expects everything to be done to him and for him. He goes to stay in mostly similar hotels, travels by almost entirely similar airplanes, trains or cars, and visits all the places which he came prepared to see (or rather, to photograph). In actual reality, the tourist is completely insulated from the landscape he traverses. Even once he arrives at a destination, he is totally insulated from natives.

Indeed, these tourists who have already consumed an array of exotic and glamorized photographs of the place before arrival, *search out these very images and sites* to visit and photograph in order to feel that their trip is complete. While many of the experiences revolve around architectural monuments, the desire to consume exotic/ anthropological images of people has found a new trade, which has its parallel in the earlier studio-anthropological photography. In many tourist attractions – West or East – men and women sit in elaborate garb, which the tourist can recognize as traditional and, more importantly, exotic. These people wait for those willing to pay to have their photograph taken with them.

Thus, as Boorstin argues, foreign travel has ceased to be an activity – an experience, an undertaking – and instead became a commodity. The rise of the tourist was possible, and then inevitable, when attractive items of travel were wrapped up and sold in packages (the "package tour") to people who had short periods of time available to them but wanted to experience a foreign land "instantly." By buying a tour you could oblige somebody else to make pleasant and interesting things happen to you. The rise of tourist traffic has brought the relatively recent phenomenon of the tourist attraction pure and simple. It often had no purpose but to attract in the interest of the owner or of the nation. As we might expect, this use of the word "attraction" as "a thing or feature which 'draws' people; especially any interesting or amusing exhibition" dates only from about 1862. It is a new species: the most attenuated form of a nation's culture. All over the world now we find these "attractions" – of little significance for the inward life of a people, but wonderfully salable as tourist commodity. Examples are Madame Tussaud's wax museums, Tiger Balm Gardens in Hong Kong, Disneyland in California and so on.

Instant Gratification

The transition of travel into tourism was accompanied by a desire for instant gratification, or 'home delivery' of adventure. The tourist had limited time and wanted to experience the exotic life of far-off places. Photographic companies such as Eastman Kodak capitalized on this trend, even going to the extent of creating performances of the natives for the benefit of tourists ready with their new Kodaks (EKC regularly organizes the Hula dance by a group of professionals in Hawaii for example, where hundreds of people click away their Kodaks several times a day, satisfied at having witnessed and recorded a 'native' event). Needless to state, these instant vacation packages reinforced the expectation of the tourist that things would be delivered in his/her lap. The activity of photography was undergoing a similar transformation, whereby people wanted their snapshots developed as soon as they had taken them.

The increasing 'automation' of life and the proliferation of 'versatile solutions for modern living' served to reinforce this expectation of instant gratification. While the booming economy in America elevated the standard of living that the middle-class enjoyed, it also brought in a whole flux of instant foods and ready-to-wear clothes. Custom-tailored clothes were now associated with a rapidly fading image of aristocracy and women, back into kitchens after the war, began to use all the gadgetry that came out of several years of research and development (mainly conducted during the war). Whether at home or abroad, increasing automation and homogenization created a culture where people came to expect instant gratification in food, clothes, or any other purchase. The wait was being squeezed out from the time people ordered their merchandize to final delivery.

THE MOTIVATION BEHIND PHOTOGRAPHY: INDIVIDUAL OR SOCIAL?

The timing was thus perfect for Polaroid's arrival. Photography had slipped from the domain of precision-oriented adventurers or professionals into the hands of ordinary people who carried it out in a regularized pattern (on standardized, instant vacations, social occasions, etc.). While at one time using a camera was a more individualized decision (the photographer was an adventurer, an artist, and a scientist all at the same time) the motivation was now becoming more social (photographs were now being taken in social situations, with the focus shifting from the technological process to social dynamics). The space in which photography was practiced had expanded, as had the range of subjects, but there was a clearly discernable pattern in popular photography. The same occasions, weddings, parties, vacations, and other social occasions seemed to prompt individuals from diverse backgrounds to click their cameras. It is indeed illustrative how no moment, other than those socially sanctioned, seems inviting to snap-shooters. Similarly, most photographs depict similar subjects, friends, relatives, children, tourist sights and so on.

The transformation of photography from a specialized activity to a general, popular one involved a fundamental change in its meaning. Whereas at one time, picture-taking was a serious, solemn business, it had grown to be a 'fun' activity for the masses. In addition to any desire to 'preserve memories,' an element of social excitement and celebration had been added to photography. Polaroid appealed immensely to such a society because it injected life into these occasions. It gave people a 'fun' activity that could bring a dead party to life, reinvigorating the ritualized socializing situations. The shared experience of watching an image materialize before eager eyes provided brought joy and yet another occasion for celebration.

Pictures were not only artifacts containing memories, but served several other functions too. Before Polaroid, viewing pictures had provided a social occasion for celebration. Thus, Bourdieu quotes Mlle B.C. Grenoble (Isere) from an issue of the magazine Elle (14 January, 1965, 'Les lectrices bavardent (Readers chat)),

> "In a large family, everyone knows that even good understanding cannot prevent cousins, uncles and aunts from sometimes having stormy or wearing conversations. Whenever I feel that tempers are fraying I take out our family photograph album. Everyone rushes over, everyone's amazed, they rediscover themselves, as babies and teenagers. There's nothing like it for calming them down, and everything settles down again" (Bourdieu, 1996).

Polaroid fulfilled a similar purpose of congregating a family or any group of people gathered socially. It brought families together instantaneously, providing an activity for adults with which they could impress children and entertain friends. That the outcome, the photograph, was not of exceptionally high quality, at least initially, did not seem to bother anyone! Similarly, photographs provided 'proof' of a person's status (pictures with celebrities and important people), cosmopolitan outlook (pictures in various international locations), credibility (pictures at important occasions) and so on. Similarly, possession of high-end cameras carried implications regarding the status and technical know-how of the owner. Indeed, Bourdieu's research showed there to be little correlation between ownership of expensive, sophisticated cameras and technical knowledge of their operation (1996). On the other hand, there was a strong positive correlation between the income of a person and ownership of an expensive, sophisticated camera [Bourdieu, 1996].