Sourcing of Innovation as Trendsetting in the Imaging Sector

Johannes M. Pennings*
Department of Management
The Wharton School – University of Pennsylvania
Locust Walk Suite 2000 Steinberg Hall-Dietrich Hall
Phone +1 215 898 3560
e-mail: Pennings@wharton.upenn.edu

&

Gino Cattani
Department of Management
The Stern School – New York University
Tisch Hall
Phone +1 12129980264
e-mail: gcattani@stern.nyu.edu

February 2006

Paper Presented at the Klein Symposium Penn State University, October 15-17, 2005. Research support was generously provided by the Mack Center at the Wharton School of the University of Pennsylvania. We also gratefully acknowledge the advise and assistance of Juan Alcacer, Dasapich Thongnopnua and Le Truong. Micropatent provided the data on patenting and their forward, backward citations in highly readable format.

ABSTRACT

The paper presents a preliminary framework of industry evolution taking the photographic sector as a case for documenting the role of firms in shaping the trajectory away from chemical to electronic based imaging. During the three most recent decades this sector has evolved from a dominant design that relied heavily on silver halide towards designs that are strongly embedded in the computer hardware and software domain of knowledge. The evolution spanned Japan, the US and EU and entailed the recombination of existing and new bundles of knowledge which is more or less unique to different firms. Exploring patent citations across many patent classes, we present an analysis of a six firms whose combinative roles are shown to shape the evolutionary trajectory of their sector. Firms might be cast in the role of broker depending on the extend they amass bundles of knowledge which have both firm and inter-firm or sector specific origins. The results suggest that an understanding of industry evolution should draw from institutional, technological, historic-geographic and firm specific observations.

Sourcing of Innovation as Trendsetting in the Imaging Sector

"Photography appears to be an easy activity; in fact it is a varied and ambiguous process in which the only common denominator among its practitioners is in the instrument" - *Henri Cartier-Bresson*

A major challenge for representing the evolution of an industry or market involves its multi-level nature in a wide range of disciplines. Industry boundaries are difficult to pinpoint, their onset or demise even less so. Mapping out changes that might either be endogenous (e.g., by the conduct of incumbents and/or their spin-offs) or exogenous (e.g., through the role of new entrants or regulators within such domains) are therefore fraught with many difficulties. We present a new attempt at documenting industry or sector evolution. We do so by focusing on imaging, confining ourselves to its most recent decades (1975-2005) during which it has witnessed a dramatic paradigm shift, with concomitant transformations across the globe and among various value chains including still and movie images, photocopying, lithography and distribution to equipment for image capturing, editing and publishing.

Industry evolution can be understood through the lens of biology (e.g., Hannan and Freeman, 1984; Levinthal, 1997; Cattani, 2005), industrial and institutional economics (Dosi, 1982; Nelson and Winter, 1982; Klepper, 2002), entrepreneurship (e.g., Schumpeter, 1934; Aldrich, 2002), institutional theory (e.g., DiMaggio and Powell, 1983; North, 1990), and history (e.g., Chandler, 1962; Morkyr, 1990; Murmann, 2003). Evolutionary trajectories and their disruptive transitions have been conceived as being triggered by managerial or entrepreneurial decision making, by regulatory fiat (e.g., Rosenkopf and Tushman, 1998) or collusive conduct (e.g., Rosenbloom and Cusumano, 1987), by cognitive and cultural inertia (Christensen, 1997), perhaps in combination with firm selection, whether internal (e.g., Burgelman, 1994) or external (e.g., Hannan and Freeman, 1984) to the organization, and finally by national context conditions (e.g., Landes, 1969). Clearly, the range of disciplines, the levels of analysis and the choice of endogenous and exogenous triggers to account for changes in markets and industries produce major challenges in explaining if not predicting the technological trajectory and its successive paradigms.

An exploration of the factors that induce directionality in industry evolution with disruptive or discontinuous changes motivated this paper. Most sectors comprise numerous agents, individuals, regulators, firms and clusters of firms in the form of associations, cartels and consortia. Yet the boundaries of what defines an industry are often difficult to identify. The reliance of SIC codes and other efforts at identifying sector boundaries is most tenuous – although industries so defined continue to be the most prevalent setting (or sample) for conducting studies in industrial organization (e.g., Klepper and Simons, 2000) and strategic management (e.g., Witt, 1998). The implied boundaries are blurry rather than sharp, putative boundary sharpness often being assumed in industrial organization economics, with conventional focus on categories like SIC notwithstanding.

We confine ourselves to the most recent decades of what might be called the photographic sector and explore the innovative productivity of firms as individual and collective agents of change. We focus on 12 large and small, old and young, Japanese, American and European firms within an evolving sector whose shifting boundaries are still in a state of turmoil, and capture the extent to which they mediate the bundling of complementary knowledge towards emerging dominant designs. The design of this exploration is therefore multi-level considering the interaction between firms and their sector. More specifically, the focus is on firms' mediation through a patent-based network through which their knowledge base becomes connected or marginalized. By tracing their cumulative R&D output to and from peer firms we attempt to account for their impact on subsequent developments in the imaging sector. We do so by contrasting some large, (Kodak, Fuji and Sony) with medium (Adobe) and small (Indigo and interactive Pictures). By varying the size to include MSE firms across the globe, the study might hint at the combinative role of old and new knowledge as the sector converges towards new dominant designs.

Theory

The evolution of an industry, market or sector can be articulated by the successive dominant designs which firms subscribe to (e.g., Abernathy and Utterback, 1978; Utterbarck, 1996). We believe that the imaging sector constitutes an attractive setting for mapping successive paradigms. Furthermore, its boundaries are rather fluid such that inclusion of firms, their knowledge base and the conversion of that knowledge base into products or components have been subject to important discontinuities. Finally, its subfields are constantly rearranged into new and modified configurations.

The rise and fall of industry standards (paradigms or dominant designs) in a given sector coincides with evolving sets of firms, whose fortunes rise and decline with the dominant design to which their current legacy is attached. The death of a dominant design, for example the microprocessor or 35 MM camera, triggers waves of bankruptcies, as illustrated by Braun and MacDonald's (1985) study of the semiconductor or Christensen's (1997) study of the disk drive industry, respectively. Firms play a significant role in driving their collective evolution.

By their combinative capabilities firms might bundle knowledge and thus produce new products or components that become key in the emergence of new products. Other firms might be more prone in consolidating and institutionalizing bundled knowledge and the associated products through their networking with other firms. In other words, a dominant design might be crafted through the combination or integration of previously loosely coupled knowledge, and become legitimized or widely accepted through the participation of firms into an emergent dominant design. Such firms' role is framed in terms of *brokerage* or *closure* (compare, Burt 2005). As "broker" the firm combines the disparate knowledge of peers, while firms that forge the acceptance of newly integrated knowledge into emergent paradigms do so through their embeddedness in critical locations.

Much of the research to date has been retrospective by documenting the legacies of firms and their prevailing routines, practices or institutions. The old dominant design becomes partially or completely replaced through regulatory intervention, substitution and network effects of new products or services whose price-adjusted quality outperforms predecessors; or through the erosion of established social order, as enunciated by institutional schools in economics and sociology. The sector then tips towards a new era, displacing many of its incumbents while accommodating new entrants (e.g., Lee et al., 2005).

The above mentioned issue of sector boundaries complicates any theorizing or empirical research on market or industry evolution and firm conduct because products are inherently hierarchical, with designs being part of a larger architecture while they themselves often decompose into smaller parts or complements (Simon 1962; Schilling 2000). The hierarchical architecture of products maps onto the configuration of firms and their (sub) sectors. The implication is that substitution and complementarity challenge the quest for any analysis regarding industry evolution and the evolving role of firms which are complementary in their contribution. Markets are often sequentially or hierarchically arrayed from raw materials to end products locking producers of peripheral components into dependency of dominant component producers—e.g., the micro-processor within desktop computing where far-reaching modularity is paramount (Ethiraj and Levinthal, 2004).

Such complexity is often illustrated by the sector producing the various stereo equipment components (speakers, amplifiers, MP3) and the clusters of firms that participate in the design, production, marketing and sales of such components (e.g., Roberts, 2004). In line with this argument, Schilling (2000) examines modularity and system level integration both within and between firm interoperability and what she calls "combinationability." Yet, we need some articulation of boundaries to circumscribe a sector which, as we will see shortly, can be done operationally by an implicit self-definition of the sector–-in this study, the imaging industry through the patent citations patterns of their firms.

It is the conduct of firms at the intersection of evolving boundaries that is at the core of our inquiry regarding sector evolution and the associated rise and fall of dominant designs. The presumption is that the more or less checkered integration of knowledge among subfields engenders the rise of new knowledge which subsequently becomes solidified into coherent bodies of new knowledge and organized around the architecture of a new dominant design.

Patents and Patent Classes

Many sectors can be decomposed into subfields, and in fact the literature on strategic groups (e.g., Porac and Thomas, 1990; 1995; Porac et al., 1995) suggests a certain amount of discontentment with prevailing arbitrary classifications such as the SIC code and other commonly used categories such as those illustrated by Fortune magazine and census categories used in EU or Japan. The unbundling and bundling of subfields is a phenomenon of considerable interest, with patent classes and their subclasses becoming a prominent method for documenting trajectories among sectors, however narrowly delineated (e.g., Fleming, 2001; Ziedonis, 2004). Incumbency becomes a fluid or tenuous identity for sector membership.

Capturing knowledge flows within and between sector-defined fields becomes feasible when examining patents through their backward and forward citations, and constitutes the input for a methodology for tracing the pathway of innovative trajectories in the imaging sector since 1975. The flows intersect to engender new paradigms and might become consolidated, depending on type and number of firms and their clientele joining the bandwagon.

Data on patents and patent citations lend themselves towards the delineation of a sector, partly because patents are quite explicit regarding the application for a product or service, and patent citations convey new claims that set them apart from 'prior art' and its claims. Patents, as classified into classes and subclasses, allow also a more or less institutionalized demarcation of knowledge fields and the claims (possible applications) that are associated with them. Patents document new, non-obvious inventions and assign rights to its owner, usually a corporation, with so called 'claims' – i.e., attributes of the invention over which the firm, or inventor exercises sole property rights. Patents typically cite other patents and publications to differentiate the new claims from those that fall under prior art. Mapping patents and their citations will thus implicitly produce a more or less bounded field that might be classified as a sector. Some authors have gone so far as exploring the concordance between patent and standard industrial classes (compare Silverman, 1999).

The connection between a patent and its prior art amounts to forms of networking between platforms of knowledge. Depending on whether prior art falls within the narrow scope of the new patent or is historically more remote would suggest an opportunity for tracing innovations on their degree of continuity. The innovation literature is replete with notions of incremental, continuous versus radical, frame-breaking discontinuities (e.g., Abernathy and Utterback, 1978; Tushman and Anderson, 1986; Anderson and Tushman, 1990; Mokyr, 1990). When viewed in the context of patenting, radical innovations signal the observable evolution of a sector, but as indicated before, innovations do not only depend on their articulation by novel art, but also by the growing acceptance of that novel art in its diffusion throughout the sector. As we will observe, some firms are important agents of change while others act to consolidate their sector into a coherent and well synthesized cluster with one or a few standards.

We examine patents and the connections among them through citations so that firms can stand on the proverbial shoulders of other firms. As patents and their owners converge (e.g., Jaffe et al., 1993), through R&D outputs and their relationships with those of others, webs of knowledge can be constructed in terms of backward and forward citations. When patents cite other patents, they acknowledge their dependence on prior art, including home-grown art, often described as self-citations. By contrast, forward citations reveal the impact a firm's patenting on peer firms innovative output whether the same technological domain(s) or a different one. When the intensity of citations declines, the focal firm's IP stock shows sign of decay and *ipso facto* diminished importance.

The patents as knowledge-codified output become embedded in a knowledge network that can be aggregated to the level of the inventor or the firm that employs her. Firms can thus be placed into a web based on patent citations fanning backward into the past or forward into the future, and reveal themselves as knowledge reservoirs. A firm might cite patents that are more or less remotely removed form its legacy. When remote, the firm is sometimes viewed as behaving in an "explorative" rather than "exploitative" manner (March, 1991). Self-cited patents or patents close to their legacy amount to a deepening and consolidation of proprietary knowledge and might constitute the pinnacle of entrenchment and exploitation (Rosenkopf and Nerkar, 2001). Backward citations reveal the extent to which a firm bundles other firms' knowledge and is particularly critical when other firms' knowledge remains fragmented and unconsolidated. This notion of bundling or combining other firms' knowledge or intellectual property is central in brokering knowledge evolution. A multi-level approach to sector evolution is, therefore, desirable.

Firms and Evolution of Their Sector

Firms constitute the elements of a (strategic) group, a community of knowledge or practice and produce dynamics which in turn revert from their community into the conduct of firms: whence the argument that multi-level designs are required for tracing evolutionary trajectories. Patents belong to classes and subclasses, whose stock is generated by individuals and the firms which employ them, which can be mapped through the networks that tie them together. Patent citations constitute form of organizational social capital. Each patent can be read as an announcement to an audience as selected by the firm or its patent examiner. As asset, such implicit network conveys (according to Bourdieu and Wacquant, 1992) resources, actual or virtual, that accrue to a firm by virtue of possessing a lasting network of more or less institutionalized relationships as embodied in documented knowledge flows.

Social capital thus construed entails minimal levels of cognitive awareness, unlike individuals as sentient actors engaged in exchange relationships. The network relationships are largely assumed for the interconnectedness imputed to citation patterns. The diminished awareness does not detract from the connections between observable flows of research that we assume to embody an evolving institutional, shared and normative context and represent a clustering of firms as repositories of knowledge, which is continuously assembled and disassembled and eventually becomes further bundled through the creation of industry associations, regulatory oversight, and heightened M&A activity and joint ventures.

A firm tends towards "brokerage" (Burt, 2005) to the extent that it produces greater knowledge variability through inter-firm *combinative* behaviors. Combinative flows have been attributed to firms, and whence their innovative achievements through the knowledge management arrangements which are so common in today firms, but we should be equally observant of the synthesis of knowledge across firms. Patent citations amount to bridges that span pools of knowledge between firms.

Following Burt (2005), firms (as any other actor—whether individual or higher social aggregate) can be viewed as a potential mediator in integrating divergent networks. He advances the term "constraint" to describe the condition where an actor is unencumbered or confined in navigating through its sector. When over-embedded any interaction with a contact (often called "alter") might have repercussions on contiguous relationships, thus constraining the focal actor. In contrast, when such actor is connected with alters who among themselves are minimally connected, or who are separated by "structural holes," the focal actor becomes inoculated from their pressures and is relatively unconstrained. Opportunities for brokerage abound. Burt (2005) proposes a so-called constraint score for identifying the topography of firms -- or other classes of actors such as people or patents within the network. In the present case we generate patent-citations derived C_{ij} scores — which are computed as follows:

$$C_{ij} = (p_{ij} + \Sigma_q p_{iq} p_{qj})^2 \qquad \text{for } q \neq ij$$

where p_{ij} is the proportion of firm i's patenting link with firm j [p_{ij} is equal to $z_{ij} / \Sigma_q z_{iq}$ with z_{ij} measuring the zero to one citation strength between firm i and firm j]. The total amount that is between parentheses represents the proportion of firm's i citations towards firm j whether directly or indirectly through firms q. The sum of the squared proportions $\Sigma_i c_{ij}$ is the citation network constraint score, C. Computational details are provided in Burt (1992). While the firms as actors thus construed do not represent the sentient actors in contact, advice or trust networks (see Krackhardt, 1999) we can nevertheless represent firms in citation networks as mediators or consolidators between other firms in their quest to push knowledge frontiers.

Patents and their citations represent information on inter-firm networking and inform the firms' role in crafting and consolidating knowledge in their sector. We then examine a small set of organizations that differ in size and geographic location to investigate this role. These firms might differ in their embeddedness in the sector, depending on what other firms they cite in their patenting activities. If strongly embedded they perform less likely in some combinative capacity and are less likely to drive the evolution in the sector.

The imaging sector appears eminently suited for such an inquiry, not only because it shifted from chemically to being electronically based, but also because imaging entails the novel bundling of disparate products and their underlying knowledge, ranging from storage, distribution, editing and other functionalities. This sector is rife with strategic groups, the bridges between which might play a critical role in grasping sectoral evolution. Their evolutionary significance is traced by assessing the firm's impact as inferred from its forward citations (see below).

The Imaging Sector

Imaging is one of many sectors that have gone through numerous paradigm shifts. A vast literature exists already on industrial evolution and technological paradigms, furnished by a vast literature from historians, economists, engineers and sociologists (e.g., Sahal, 1985; Klepper, 1997; Christensen, 1997)--from sail power, computer storage and steam engines to radio transmission, telecommunication and retail sales. The innovation literature is replete with research on successive paradigms, the demise of incumbents, the waves of creative destruction and the entrepreneurial activity that rides on them (e.g., Dosi, 1982). In many sectors, the prevailing trajectories are neither neatly bounded nor do we observe the emergence of a singular design, although it is tempting to represent the history of an industry in terms of a linear process culminating in peaks and valleys. It would also be tempting to envision imagery in the imaging industry. Rather paradigms are embedded in various architectures or represent the architectures as such (Henderson and Clark, 1990; Baldwin and Clark, 2000)—compare film, photography, xerography and scanning.

This setting has been evolving over the last three decades, although imaging, of course, been a central feature since the onset of recordable or accessible civilization from Lasceau and beyond. Imaging comprises many components, bundled in architectures such as movie screens, photocopies, picture albums or MRIs. It comprises artifacts, production and delivery systems, regulations, standard setting agreements and behaviors. Significant inventions dating to the earlier part of the 19th century include the glass plated images of Daguerre in 1837 and the fax machine in 1838. We confine ourselves to the more recent disruptive change associated with the rise of optical telecommunications and semiconductor technology, and cover the period 1975-2005.

Imaging as a technology, market, use function or complement to other products and services has undergone many transformations during the last thirty years, with most noticeable the electronic creation, storage and duplication of images as a discontinuous innovation from chemically based photography. Many domains within imaging such as studios, film production and movie screens are still firmly anchored in the chemical regime, while advertising and medical imaging have become more firmly entrenched in micro-electronics. Yet, even within electronic domains, we observe the retention of components (or so-called "complementary assets") that become bundled with ingredients of the new regime—a phenomenon well illustrated in Tripsas (1997)'s study of the typesetting industry. Incumbents, associated with a dying dominant design, might possess complementary assets which become bundled with chunks of knowledge that are associated with a new paradigm—in the Tripsas' example, the font library of some diehard typesetters entering the postscript era.

How do sectors evolve if they cannot neatly fit into an imagery of successive paradigms with peaks and valleys as is so common in the literature of industry evolution? The sector is highly differentiated into classes such as film, medical imaging, photocopying, photography, and embodies clusters of firms and their suppliers and customers who overlap, intersect, diverge and converge, making this sector highly complex, "rugged" or multi-peak and ill bounded. Generally it is assumed that sectors evolve through periods of reorientation and innovation (Normann, 1977), eras of consolidation and ferment, or competency enhancing and destroying periods of innovations (e.g., Tushman and Anderson, 1986; Anderson and Tushman, 1990).

Yet, as the Tripsas (1997) study demonstrates, we have ample evidence that elements of the old paradigm combine with elements of the new, while other parts are discarded; but also that a sector with fluid boundaries, and multiple performance peaks, manifest the existence of chunks of old knowledge which become bundled with elements of the new design. The death of firms need not entail the total loss of their legacy and often becomes acquired by or transferred to new generations of firms (Winter, 1994). The rise of a new (dominant) design retains elements of the old design or the sector might contain numerous domains whose coexistence defies simple announcements of a new arrival as is often insinuated with the emergence of the digital camera. Ultimately, we need to consider both brokerage and cohesion to eventually provide closure on the evolutionary trajectory of the sector (compare Fleming et al, 2005).

Background

Originating in the early eighties with the release of the first commercial digital cameras by, among other firms, Eikonix and Mavica the arena has matured over the years with participants entering from computing, electronics, and photography. The imaging arena has also seen considerable M&A and alliance activity, beginning with Kodak's acquisition of Eikonix in 1984 to the recent series of technology consortia between computing and photography firms. We therefore view this arena as having great potential for describing and explaining evolutionary patterns in market, product and technology (see Box 1 with a brief historical overview).

Trends in Inter-firm IP activity

The patenting activity of incumbents shows a clear trend away from chemical to electronic imaging technology. Many incumbents have abandoned their chemical legacy and move into micro-electronics, although some of the leading firms-some firms such as Polaroid and Agfa-Geveart are facing bankruptcy or, like Zeiss Ikon, have already exited the sector. Eastman Kodak claims to be an industry leader in both chemical and electronic knowledge accumulation, and is the frontrunner in patenting activity among imaging firms. Yet, whether patenting pre-eminence translates into being a trendsetter remains to be seen.

In the field of innovation (strategy, engineering management, etc.) studies like the one by Lee et al. (2005) indicated that diffusion of text messaging (SMS) was crucially contingent on the presence of short cuts among customers to bundle different segments. Legal trends can also be uncovered by linking jurisprudence outcroppings. Fowler and Jeon (2005) have constructed legal trajectories, distinguishing between “authorities” which are legal rulings or “opinions” cited by many other decisions and “hubs” which are opinions that cite other opinions, resulting in each case becoming rated as authority and case. The result allowed these authors to reveal the decay and ascendancy of strings of Supreme Court decisions that enjoy a certain prominence based on forward citations with the implication that its embedded position is becoming the most salient within a window of time.

In the spirit of such research traditions we likewise try to identify small or large, and US, EU or Japanese firms, enjoying a certain level of “authority” – i.e., to become trendsetters in the imaging sector based on their ability to function as a “hub” or broker. The status of broker is based on the linkages among its cited patents and differs therefore in important respects from other network studies that rely on centrality, *betweenness* and other network measures as indicated by UCINET and similar network software packages. Note that we focus on firms or assignees as brokers when mapping the evolution of the sector, much less so individuals or their “art” unless that individual is a firm rather than an employed inventor.

Backward citations signal the extent to which a firm is cast in a brokerage role. Drawing on his previous work, as well as that on the presence of small worlds (Watts, 2004), Burt (2005) has recently suggested that a firm’s network might be interpreted as placing the firm in an intermediary position between other firms. The firm's ability to be an intermediary hinges on the extent to which it bridges other firms and their knowledge. If both the focal firm and its "alters" are well connected, that firm displays diminished intermediation capacity and becomes more entrenched into a clique where it and its peers have access to the same resources and become highly subject to conformity pressures.

The implication is that imaging firms, acting as brokers, are more likely to ignite new waves of innovative activity and become more prominent in their IP status to be a central rather than a peripheral player. The trendsetting towards a new paradigm is to be inferred from the extent to which forward citations reveal that firm's impact. In the imaging sector IP decays rapidly as inferred from comparatively sharp drops in forward citation rates but important differences in hazard rates among firms can be observed.

In the exploratory analysis we carried out, we constructed for each firm a score in the imaging "sector" (it would be tenuous to define a patent derived domain or sector as market or industry; whence our preference for "sector") based on its connections to other firms as derived from backward and forward citations. A firm which becomes (more) connected to other firms which among themselves remain (less) connected will be rated more strongly as a broker and its network will have then the character of brokerage. If however the firms are well connected, both directly and even more so indirectly, their network acquires the character of "closure." The software for obtaining such metrics is provided in Burt (2005).

We surmised that broker-firms are more prominent in shaping the evolution in the imaging sector as indicated by two possible outcomes: (1) a firm's patenting impact and (2) its patent decay (or erosion of its patent library by more rapidly declining forward citations of its patents). We hypothesize that firms will enjoy more impact, endure lower patent decay and accumulate more valuable patents if they emerge as brokers.

Data

The information to explore the role of firms in driving industry evolution came from the United States Patent Office (USPTO), made accessible through NBER (Hall, Jaffe and Trajtenberg, 2001). The patents backward and future citations were made available through Micropatent, an on-line readable data base. We limited ourselves to six cases, differing in size and , geographic location with variable membership in the sector (i.e., incumbents or start-ups). They serve as illustrative cases for documenting the evolution in the imaging sector. The firms included Adobe, Eastman Kodak, Fuji, Indigo, Interactive Picture sand Sony. A follow-up paper (Pennings and Cattani 2006) examines the sector with over 19000 firms during a 30 year window in its entirety and captures the sector-wide effects of a firm's patenting activity.

As Table 2 indicates, these firms vary significantly with respect to their geographical location (US, Japan or Europe), size, overall patenting activity (i.e., number of patents) during the study period, and the number of years over which they patented in the imaging sector. These firms thus represent a good cross section of the imaging sector during the past 30 years.

Table 2 Here

As described before, we ascertained their degree of "brokerage–closure" by determining the extent to which these firms are constrained in their network, which we extracted from their patenting activity and citations to other firms in prior years (as indicated in Figure A). We also employed future patent citations to ascertain their impact so that in the six pairs of trend lines we illustrate whether brokerage and impact go hand in hand.

Figure 1 shows the temporal pattern of the 6 firms whose degree of brokerage has been calculated. While brokerage has increased among all the firms in that their social constraint as inferred from patent citations has declined, we still observe significant differences between firms, ranging from Fuji, the Japanese imaging firm among the least and Sony among the most brokering prone. Ultimately, of course, we need to consider both brokerage and cohesion in the entire sector to provide a comprehensive mapping of the evolutionary trajectory of the sector (compare Fleming et al, 2005; Pennings and Cattani 2006)).

Performance Measure: Patent Impact

In our preliminary inquiry, we measured the performance of our subset of firms in technological terms using patent future citations from other firms to estimate the value of a firm's innovative output. Although we could also use patent counts – i.e., the number of patents filed by each firm in a given year in the imaging domain – to measure the productivity of a firm's R&D activity, their use can be questioned on several grounds: firms differ in their propensity to patent; not all inventions are eventually patented; and not all patented inventions are turned into commercial applications (see Hall et al., 2001; Hall and Ziedonis, 2001). Also, many patents have little value and do not reflect any truly distinctive or significant innovation. As such, patent count is a poor proxy for the value of its patents (e.g., Griliches et al., 1987; Scherer 1965; Hall, 2000).

Especially in R&D intensive industries, the number of citations a patent receives from other patents is a more precise measure of technological performance and a better estimate of the focal patent's true value (e.g., Griliches, 1981 and 1990; Trajtenberg, 1990a and 1990b). Patents that firms report as more valuable are typically more heavily cited in subsequent patents (Harhoff et al., 1999). Previous studies have found a positive relation between firm market value and patent citations (Shane and Klock, 1997; Hall, 2000; Hall et al., 2001). Strong citation indictors also tend to be positively correlated with firm sales, profits and stock prices (see Narin et al., 2001). Strategy research has focused increasingly on the number of future citations on the premise they are a better estimate of true value of a patent and a more informative signal of success (e.g., Ahuja and Lampert, 2001; Bierly and Chakrabarti, 1996; DeCarolis and Deeds, 1999; Rosenkopf and Nerkar, 2001).

For all patents the sample firms filed over the study period we collected future citations up to April 2004 from Micropatents. Since patents filed in earlier years are exposed to the risk of being cited by subsequent patents for a longer period, we compared patents only to those filed during the same year and restricted the analysis to the period 1975-2000. As a result, on average the focal patents have remained at risk of being cited for at least 4 years. For each patent, we counted all future citations received until April 2004, net of a firm's self-citations. While self-citations measure the extent to which a firm builds upon its previous R&D efforts, citations from other firms more objectively estimate the actual relevance of a firm's patents.

Following Trajtenberg (1990a, 1990b), our performance measure estimates the impact of a firm's patenting activity and was computed as the average number of citations that all patents filed by (and then granted to) firm i (1, …, 12) in year t (1975, …, 2000) received in subsequent years (until year 2004) from patents filed in imaging by other firms. The ratio thus obtained measures the average number of future citations received by the patents filed by each firm in a given year. Since, as we noted above, "the duration for which a patent is at risk of being cited varies for patents of different vintages" (Ahuja and Lampert 2001: 531), we should compare patents only to those filed during the same year. The results of the analysis do not vary if we compute the index including also citations coming from patents filed in other classes/subclasses than those defining imaging.

Parenthetically, in a companion paper (Pennings and Cattani, 2006) the impact index as well as a patent decay index as R and D productivity indicators have been related to firm and sector characteristics:

Patent Impact or Patent Decay = f (Constraint, Size, Location, Number of Patent Classes Cited, Age, Presence before 1981 [first electronic camera launched], *Size of Firm Inventor Pool, Diversity Firm patenting, Diversity 4 digit SIC, Inventor demographics*).

In the present paper, we confine ourselves to simply plotting brokerage to innovative impact, the presumption being that the impact informs about a firm's ability to set the trend in the imaging sector.

Preliminary Results

In the six diagrams the trend lines of brokerage and innovative impact are revealed. We are presuming that shifts in patenting impact are induced by changes in the firms' brokerage behavior as implied before. Patenting impact signals a firm's disproportionate contribution to innovation in the sector. We recognize however, that these results are highly descriptive, preliminary and subject to unobserved heterogeneity.

With those caveats in mind we present pairs oif trend lines per company, beginning with Kodak and Fuji the pre-eminent incumbents, i.e., firms which figured prominently in what might be called the chemical imaging era. While this label is highly deceptive as many firms were attached to electronic or electrical, mechanical, optical and kindred platforms of knowledge, those pre-existing before 1985 were largely attached to film and paper. A firm like Kodak might recycle some complementary assets that could be recycled into the electronic imaging platforms, at least this firm being central to chemical imaging shows a diminished brokerage and a subsequent reduction in innovative impact. The trend lines for Kodak and Fuji, among the stalwarts of chemical imaging appear to clearly convey the challenge to continued brokerage as the sector undergoes a paradigm switch.

By contrast the two small firms, IndigoNV and Interactive Pictures emerge as brokering firms and manifest a near instant innovative jolt on the sector. Their impact becomes apparent as soon as they enter into to sector. Their age and size might diminish their significance as trendsetting interlopers. The start-up Indigo NV of the Netherlands was acquired by Hewlett Packard in 2000. As an intermediate case, Adobe emerges as a strong broker and a size – disproportionate impact on the development in the sector. Note that this firm is a Xerox spin-off.

We conclude with Sony—perhaps not as affected by the paradigm switch, as it appears somewhat peripheral to both the chemical and digital dominant design. The camera as image equipment is a non-leading component in the chemical era, but becomes more dominant in the digital era.

Conclusions

This paper presents an exploratory and preliminary study on patenting activity of firms in the evolving imaging sector during the period 1975-2005. We have tried to indicate that firms—whether entrepreneurial or established, US, EU or from Japan, whose patent citation activity points to a brokering role enjoys a greater impact on subsequent R&D activity as indicated by the degree its patents are cited, but also its patents are more resistant to decay. Although the sector exhibit a growing cohesion as the firms become increasingly constrained, high levels of closure do not preclude brokerage opportunities. As a result, some more central firms can still find opportunities to fill unexploited gaps and benefit accordingly. More data and data analysis is required to elaborate.

In the results we reported in the imaging sector, we tried to depict these 12 firms in terms of brokerage and cohesion. Such networks comprise firms with ties that are more or less strong (Granovetter, 1973) as implied before, brokerage exists when a firm bridges other, more or less unconnected firms (but argument could also apply to individuals or teams (Burt, 1992; Granovetter, 1973). To capture the notion of cohesion or closure, within a citation network, we could suggest that if firms link up with few other firms, they exhibit "strong" knowledge ties. Such strong and closed ties make connections to divergent networks less likely. On the opposite side of the spectrum, a firm with weak ties between itself and peer firms resides in a patent derived network that is non exclusionary and exhibit bridges among firms with divergent IP.

During the break up of conventional photography, a firm's insular patenting -- self cited or cited patents of near by peers such as those belonging to its strategic group or community of knowledge (Teigland, 2002)-- produces narrow-mindedness and the reuse of pre-existing knowledge and information, The implication is that firms with open citation networks stand to break newer grounds, to set the stage for new technology platforms, in short to become disproportionately prominent in crafting new product-market designs through the intermediate firm. Cohesion is its inverse. Closure exists when the firm and its peers connect with each other directly, not through the focal firm (compare, Coleman, 1988). In other words, in line with Coleman's discussion, we can view closure as a form of social capital that entails a very dense and overlapping ties between the various firms' IP (Coleman is more concerned with face to face contacts among individuals and refers to trust as a key attribute).

Our preliminary results indicate an overall decline among the twelve cases of this study towards diminished brokerage and growing closure – which is partly the result of an increased level of connectedness among firms within the industry over time. The initial results that are most compelling is that incumbents (i.e. imaging firms present before the transition towards IT) witness a decline in innovative impact together with concomitant if not somewhat delayed diminished brokerage and increased closure, while start ups make noticeable contributions in innovation as proxied by patenting impact.

In conclusion, we would like to emphasize that despite their many useful applications patent data exhibit some shortcomings as well. While patents have been increasingly used as a measure of firm knowledge, and citations as knowledge networks, they do not fully measure a firm's overall base of experience. For instance, even though reference to prior art – i.e., citations to patents by other firms – has been a core methodology in research on social, organizational, and geographic pathways of knowledge flows, citations made by patent examiners have not been separated out from citations made by inventors (Alcacer and Gittelman, 2004). Focusing on a single industry, like in this paper, where patents are important for appropriating returns to R&D might significantly reduce the effect of this problem, which is on the contrary compounded in studies comparing knowledge flows across very different industries. Of course, similar problems afflict most empirical measures, especially those measuring intangibles such as skills and knowledge.

The subsequent research requires us to examine the evolving anchoring of firms in certain knowledge domains as revealed by the preponderance of its R&D output in one or more patent classes. Firms are more or less specialized and might scatter their R&D activities over narrow or wide range of knowledge domains. The spread as revealed by an index such as herfindahl shows a firm to be only attached or detached to a given niche, but also whether that attachment is towards the prevailing paradigm or dominant design. The legacy that might surface by tracing a firm's intellectual property, when combined with brokerage or cohesion will inhibit a firm's ability to move towards a new and discordant platform—an impression which is signaled by incumbents' failure to have an impact on the evolution of emerging designs. We should examine the firms' diversity against a backdrop of sector wide diversity (compare Wezel, Boone and van Witteloostuijn, 2005).

We should also explore whether the firms' inventors contribute to a firm's entrenchment, if any since inventors also function as potential intermediaries in bridging pools of knowledge. That bridging is discernable across patent classes, but also across firms and their geographic location since knowledge is notoriously sticky, sticky to firms and to territory (Trajtenberg et al., 1999).

The results so far do not reveal anything about the relative prominence of firms in driving the innovative trajectory in the sector. To represent such a comprehensive trend we need to include all firms in the sector—over 19000 firms in our data set. Such an analysis might also expose multiple dominant designs. While imaging involves the image in all its shapes and forms including still photographs, movies and diagnostics, its complements such as its capture, distribution and use functions, in widely divergent settings such as consumer electronics, military intelligence, medical diagnostics, entertainment and the arts. Any of these ill-bounded areas might acquire its own unique dominant design, suggesting that the imaging sector is a multi-peaked landscape. Depicting that landscape and understanding its dynamics as it emerges during the conduct of this study is an elusive but possible achievable objective.

References

Abernathy, W. J., and J. Utterback (1978). Patterns of industrial innovation. Technology Review, 50: 40-47.

Anderson, P., and M. Tushman (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. Administrative Science Quarterly, 35(4): 604-633.

Ahuja, G., C. M. Lampert. 2001. Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. Strategic Management J., 22: 521-543.

Albert, M., D. Avery, F. Narin, P. McAllister (1991). Direct validation of citation counts as indicators of industrially important patents. Research Policy, 20(3): 251-260.

Alcacer, J., M. Gittelman (2004). How do you know what you know? Patent examiners and generations of patent citations. NBER, Summer Institute.

Baldwin, C. Y, K. B. Clark (2000). *Design Rules: The Power of Modularity*. Cambridge, MA: MIT University Press.

Baum, J. A. C., P. Ingram (1998). Survival-enhancing learning in the Manhattan hotel industry, 1898-1980. Management Science, 44(7): 996-1016.

Benner, M. J., M. Tushman (2003). Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. Academy of Management Review, .

Bierly, P., A. Chakrabarti (1996). Generic knowledge strategies in the US pharmaceutical industry. Strategic Management Journal, 17: 123-135.

Burgelman, R. A. (1994). Fading memories: A process theory of strategic business exit in dynamic environments. Administrative Science Quarterly, 39(1): 24-56.

Burt, R. S. (1992). *Structural Holes*. Cambridge, MA: Harvard University Press.

Burt, R. S. (2005). *Brokerage & Closure. An Introduction to Social Capital*. Oxford, UK: Oxford University Press.

Chandler, A. D. J. (1962). *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. Cambridge, MA: MIT Press.

Christensen, C. M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard Business School Press.

Coleman, J. S.(1988) "Social capital in the creation of human capital." American Journal of Sociology, 94: S95-S120.

DeCarolis, D. M., D. L. Deeds (1999). The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. Strategic Management Journal, 20: 953-968.

Dimaggio, P. J., W. W. Powell (1983). The Iron Cage revisited: Institutional isomorphism and collective rationality in organizational fields. American Sociological Review, 48(2): 147-160.

Dosi, G. (1982). Technological paradigms and technological trajectories. Research Policy, 11: 147-162.

Ethiraj, S, D. A. Levinthal (2004). Modularity, Innovation in Complex Systems. Management Science, 50(2): 159–173.

Fleming, L. (2001). Recombinant uncertainty in technological search. Management Science, 47(1): 117-132.

Fleming, L. Mingo, S and Chen. D (2005) Brokerage versus Cohesion and Collaborative Creativity: An Evolutionary Resolution, Working paper, Harvard Business School.

Fowler, J. H., and J. Sangick (2005). The authority of Supreme Court precedent: A network analysis. Working Paper, UC Davis, CA.

Granovetter, M .(1973) "The strength of weak ties." American Journal of Sociology, 78: 1360-1379.

Griliches, Z. (1981). Market value, R&D and patents. Economic Letters, 7: 183-187.

Griliches, Z. (1990). Patent statistics as economic indicators: A survey. Journal of Economic Literature, 28: 1661-1707.

Griliches, Z., A. Pakes, B., H. Hall (1987). The value of patents as indicators of inventive activity. P. Dasgupta, P. Stoneman (eds.), *Economic Policy and Technological Performance*. Cambridge, England: Cambridge University Press.

Hall, B. H. (2000). Innovation and market value. R. Barrell, G. Mason, M. O'Mahoney (eds.), *Productivity, Innovation and Economic Performance*. Cambridge: Cambridge University Press.

Hall, B. H., A. B. Jaffe, M. Trajtenberg (2001). The NBER patent citations data file: Lessons, insights and methodological tools. NBER working paper series No. 8498. Cambridge, MA.

Hall, B. H., R. Ham-Ziedonis (2001). The patent paradox revisited: An empirical study of patenting in the US semiconductor industry, 1979-1995. Rand Journal Economics, 32(1): 101-128.

Hannan, M. T. (1984). Structural inertia and organizational change. American Sociological Review, 49: 149-164.

Henderson, R. M., K. B. Clark (1990). Architectural Innovation: The reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly, 35(1): 9-30.

Jaffe, A. B. (1986). Technological opportunity and spillovers of R&D: Evidence from firms' patents profits and market value. American Economic Review, 76(5): 984-1001.

Jaffe, A. B., M. Trajtenberg, R. M. Henderson (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics, 108(3): 577-598.

Jaffe, A. B., M. Trajtenberg (2002). *Patents, Citations, and Innovations: A Window on the Knowledge Economy*. Cambridge, MA: MIT Press.

Klepper, S. (1997). Industry Life Cycle. Industrial and Corporate Change, 6(1): 145-181.

Klepper, S., K. L. Simons (2000). Dominance by birthright: Entry of prior radio producers and competitive ramifications in the US television receiver industry. Strategic Management Journal, 21: 997-1016.

Klepper, S. (2002). The capabilities of new firms and the evolution of the US automobile industry. Industrial and Corporate Change, 11(4): 645-665.

Lee, J., J. Song (2006). Incompatible entry in small-world networks. Management Science, forthcoming.

Levinthal, D. A. (1997). Adaptation on rugged landscapes. Management Science, 43: 934-950.

March, J. G. (1991). Exploration and exploitation in organizational learning. Organization Science, 2(1): 71-87.

Mokyr, J. (1990). Punctuated equilibria and technological progress. The American Economic Review, 80(2): 350-354.

Murmann, P. (2003). Knowledge and Competitive Advantage. The Co-evolution of Firms, Technology, and National Institutions in the Synthetic Dye Industry. Cambridge, UK: Cambridge University Press.

Narin, F., E. Noma, and R. Perry (1987). Patents as indicators of corporate technological strength. Research Policy, 16(2-4): 143-146.

Narin, F., P. Thomas, and A. Breitzman (2001). Using Patent Indicators to Predict Stock Portfolio Performance. B. Berman (ed.), *From Ideas to Assets: Investing Wisely in Intellectual Property*, 293-308. New York: John Wiley & Sons.

Nelson, R. R., S. G. Winter (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.

Normann, R. (1977). *Management for Growth*. New York, Wiley.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge, UK: Cambridge University Press.

Pennings, J.M and Cattani, G (2006). Paradigm shifts: the case of brokerage and closure in the imaging sector. Working paper, The Wharton School, University of Pennsylvania.

Porac J. F., H. Thomas (1990). Taxonomic mental models in competitor definition. Academy of Management Review, 15(2): 244-240.

Porac, J. F., H. Thomas, F. Wilson, D. Paton, and H. Kanfer (1995). Rivalry and the industry model of the Scottish knitwear producers. Administrative Science Quarterly, 40(2): 203-227.

Rosenbloom, R. S., M. A. Cusumano (1987). Technological pioneering and competitive advantage: The birth of the VCR industry. California Management Review, Summer, 29(4): 56-76.

Rosenkopf, L., M. L. Tushman (1998). The Coevolution of community networks and technology: Lessons from the flight simulation industry. Industrial and Corporate Change, 7: 311-346.

Rosenkopf, L., A. Nerkar (2001). Beyond local search: Boundary-spanning, exploration, and the impact in the optical disk industry. Strategic Management Journal, 22: 287-306.

Sahal, D. (1985). Technological guideposts and innovation avenues. Research Policy, 14: 61-82.

Scherer, F. M. (1965). Firm size, market structure, opportunity, and the output of patented innovations. American Economic Review, 55: 1097-1123.

Schilling, M. A. (2000). Towards a general modular systems theory and its application to inter-firm product modularity. Academy of Management Review, 25:312-334.

Schumpeter, J. A. (1934). The Theory of Economic Development. Cambridge, MA: Harvard University Press.

Shane, H., M. Klock (1997). The relation between patent citations and Tobin's q in the semiconductor industry. Review of Quantitative Finance and Accounting, 9(2): 131-146.

Silverman, B. S. (1999). Technological resources and the direction of corporate diversification: Toward an integration of the resource-based view and transaction cost economics. Management Science, 45(8): 1109-1124.

Simon HA. (1962). The architecture of complexity: Hierarchic systems. Proceedings of the American Philosophical Society, 106: 467-482.

Trajtenberg, M. (1990a). A penny for your quotes: Patent citations and the value of innovations. RAND Journal of Economics, 21(1): 172-187.

Trajtenberg, M. (1990b). *Economic Analysis of Product Innovation*. Cambridge, MA: Harvard University Press.

Trajtenberg, M., R. M. Henderson, A. B. Jaffe (1997). University versus corporate patents: A window on the basicness of invention. Economics of Innovation and New Technology, 5(1): 19-50.

Tripsas, M. (1997). Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry. Strategic Management journal, 18: 119-142.

Tushman, M. L., and P. Anderson (1986). Technological discontinuities and organizational environments. Administrative Science Quarterly, 31(3): 439-465.

Utterback, J. M. (1996). Mastering the Dynamics of Innovation. Boston, MA: Harvard Business School Press.

Uzzi, B. (1997). Social structure and competition in inter-firm networks: The paradox of embeddedness. Administrative Science Quarterly, 42(1): 35-67.

Wezel, F, Boone, C and vn Witteloostijn, A (2005). An Ecological Theory of Population-Level Diversity. Working Paper, Department of Economics, Tilburg Univrsity.

Winter, S. G. (1994). Organizing for continuous improvement: evolutionary theory meets the quality revolution. In J. A. C. Baum and. J. V. Singh, (eds.), *Evolutionary Dynamics of Organizations*. New York: Oxford University Press.

Watts, D. (1999). Small Worlds: The Dynamics of Networks Between Order and Randomness. Princeton, NJ: Princeton University Press.

Ziedonis, R. H. (2004). Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. Management Science, 50(6): 804-820, 2004.

Box 1 – Imaging: A brief history and an overview of the technology from chemical to electronic engineering

Electronically based imaging is gradually replacing chemically based imaging. The key element of the latter is silver halide which when interacting with light waves becomes transformed into an image and can be transmitted from film to paper, or projected onto some other medium like a screen. Digital or electronic imaging entails devices that take pictures and develop those using electrons instead of film and then transmit, store, and process these images electronically, as if they were files of data, unlike silver halide based imaging where the film and paper is covered by a layer of silver embedded substrates. NASA developed digital imaging technology in the early 1970's for its space program; this technology was closely tied to computer technology, and as costs of computer processing fell, the technology began diffusing into other areas. From the realm of consumer electronics, the development of video cameras had an impact on the way initial digital cameras were configured. Video technology had already shown that it was possible to dispense with film, though that industry remained rooted in analog technology till the late eighties. Prior to 1990, the usage of digital photography was largely restricted to a few scientific (medicine and satellite imaging) and commercial (publishing and real estate marketing) applications. The primary advantages of this technology were the ability to manipulate and edit pictures on computers and the ease and speed of development, storage, recall and transmission. With decreasing costs and increasing functionality in many of the component technologies of digital imaging, particularly semiconductors, computer hardware and software, it has since been making steady inroads into conventional, silver halide based film based imaging, as well as spawning new products and services.

Historically, digital imaging is an arena which contains participants from multiple industries including its progenitor the chemically based , silver halide photographic industry with the major players of Kodak, Agfa, Polaroid and Fuji, to whom digital imaging represents a competence destroying innovation. Another group of firms came from the consumer electronics industry (e.g. Panasonic), and typically attempted to leverage their experience with video cameras into digital imaging, particularly in the early stages of digital imaging. Yet another group of firms originated in the graphic arts and printing industry (e.g. Scitex) which had pioneered the use of electronic scanning. Finally, there were entrants from the computer hardware, software and semiconductor industries (e.g. Intel, Hewlett Packard) as digital cameras began to be accepted as computer peripherals. Digital imaging today draws on technological competencies from the semiconductor and electronics industries, computer hardware and software industries, and conventional film based imaging industries. An enumeration of the components of a standard digital camera illustrates this.

The basic image capture technology is based on the CCD (Charge Capture Device) sensor, which serves the function of converting light energy into a digital data file. The CCD technology has remained virtually dominant till recently, when CMOS (Combined Metal oxide Semiconductor) based technology has begun to replace it; sensors using CMOS sensors are about ten times as energy efficient as CCD's, and cost substantially less. The earliest versions of digital cameras did not have any storage device, thus severely constraining the portability of the instrument as it meant attachment via cables to a computer. Today, there are two major competing formats for the storage of digital photo files; removable PCMIA cards and micro drives. These are removable media, which effectively function like a roll of film. The file format in which the digital images are transferred to a computer, and then further undergo manipulation is another critical aspect of the digital camera industry. Today, there are competing alternatives available for the format in which digital imaging files can be stored, as well as for the software used to manipulate and use these data image files. Finally, there is a microprocessor chip, which controls the operation of the camera. Its key metric is speed, and size. (In addition, most present day digital cameras have an LCD display, and a lithium battery to meet the power requirements.) Related components of the architecture are printers, computers and other visual display devices.

In 2003 sales of digital cameras exceeded sales of silver halide-based or analog cameras, but movie production and screens continued to be closely tied to silver halide. See Table 1 showing the strong attachment to conventional technology in this sub sector.

. **Table 1**

Persistence of Silver Halide Technology in Imaging Sub-sector (US Movie Screens)

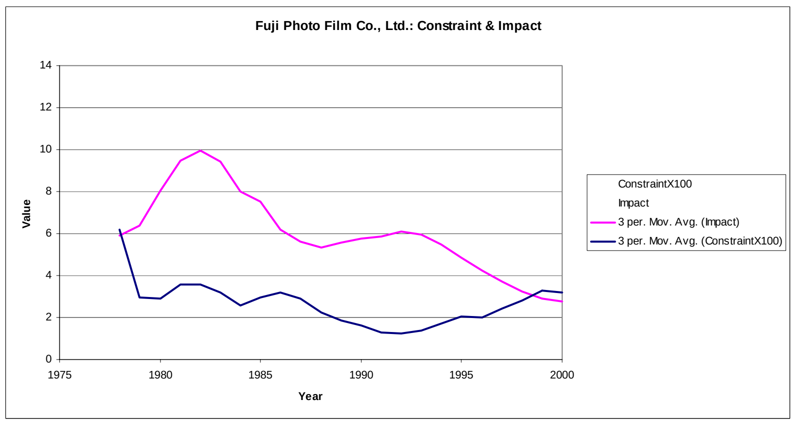
Year	Total Number of Screens	Digital Screens	# of Theaters
1999	37185	12	7551
2000	37396	31	7421
2001	36764	45	7070
2002	35280	124	6050
2003	35786	171	6066

Table 2 – Selected Firms in Imaging Sector

Firm Name	Location	Size	# of Patents	# of Years
Sony	Japan	Large	2747	29
Fuji	Japan	Large	7129	29
Eastman Kodak	US	Large	6135	29
Indigo	EU	Small	17	8
Adobe	US	Small	86	13
Interactive Picture	US	Small	10	4

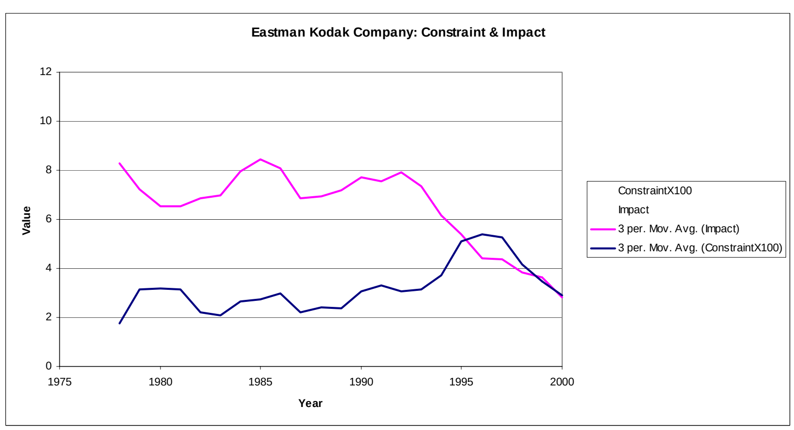
Figure 2. Pairs of Trend lines Regarding Brokerage and Innovative Impact

Fuji



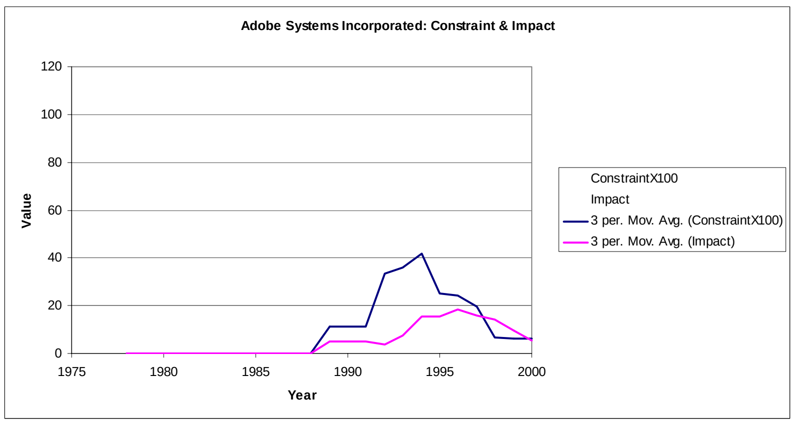
)ct2005 Klein C onf 26

Kodak

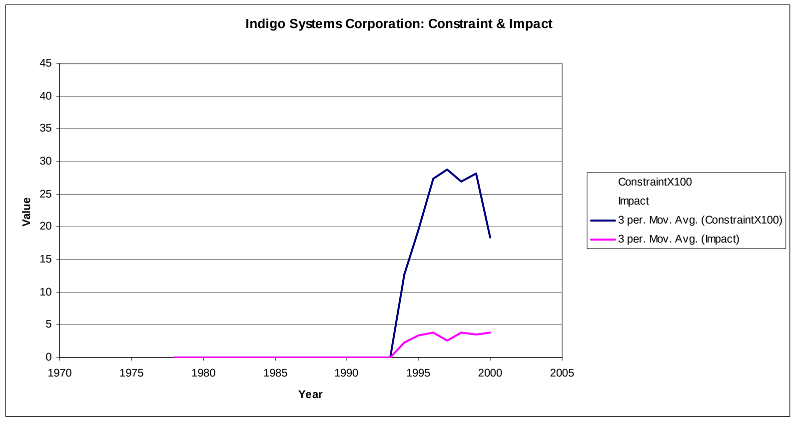


)ct2005 Klein C onf 27

Adobe, a XEROX Spin-off

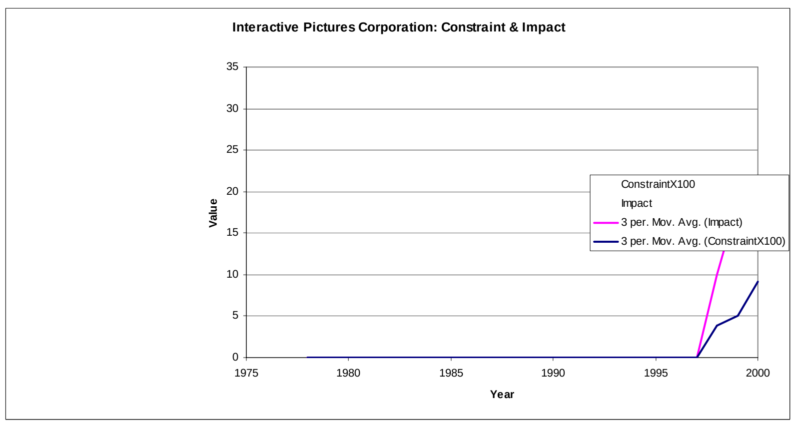


Indigo N.V. (Acquired by HP in 2000)



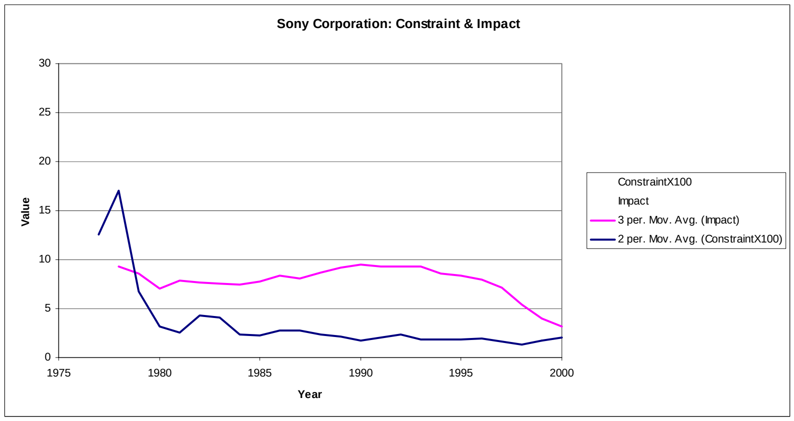
Oct2005 HHS 33

InteractivePictures



Oct2005 HHS 32

Sony



Sony Corporation: Constraint & Impact
30
25
20
15
10
5
0
Value
1975
1980
1985
1990
1995
2000
Year
ConstraintX100
Impact
3 per. Mov. Avg. (Impact)
2 per. Mov. Avg. (ConstraintX100)