Exploring Capabilities in Rapidly Evolving Product Markets: The Case of Digital Cameras

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Paper prepared for the 6th Organizational Knowledge, Learning and Capabilities Conference, Boston, March 17-19, 2005

Abstract

A substantial body of work supports the view that firm capabilities, developed via experience in the precursor industry are major determinant of success for entrants to new product markets. However, where new product innovations are not isolated occurrences but part of the diffusion of a general purpose technology, as with the surge of digital products induced by the current ICT revolution, it has been suggested that traditional capabilities may be degraded as new start-ups and outsiders with generic technology expertise or brandname advantages enter the industry. Using the digital camera as a typical example of a GPT-induced innovation and a sample of 81 early entrants to that market, this paper finds that experience in the precursor industry remains a key determinant of success and survival for new market entrants; although entrants from related industries other the precursor also appear more successful than others.

Keywords: Capabilities, Resource-Based View, General Purpose Technology

Suggested track: H Dynamic Capabilities

1. Introduction

Notwithstanding any debate over the overall testability[i] of the resource-based view (RBV) of the firm, at least one of its predictions has received very substantial empirical support: namely the importance of acquired capabilities in determining both the probability of related market entry and the survival and success of ventures following such entry[ii]. A series of empirical contributions, using diverse industries, has demonstrated that prior technological and market experience appears unambiguously important in shaping entry behavior. This finding appears particularly plausible where serendipitous invention ensures innovations occur in an irregular sequence, offering opportunities to well-positioned firms, as Richardson (1972) first argued. This paper considers what happens when multiple opportunities are created (almost) simultaneously by the diffusion of a general purpose technology (GPT). One of the defining characteristics of a GPT (Jovanovich and Rousseau, 2002) is that a wide set of related innovations are induced as the new generic technology attracts diverse applications. During the diffusion of earlier GPTs, such as water- and then steam-power, the induced developments were largely process innovations. In the more recent examples of electrification and, especially, ICT, product innovations have come to the fore in an obvious reflection of increased disposable incomes.

At the core of the current ICT revolution is the spread of digital products. Thus a whole series of innovations has occurred which either exploit the superiority of the digital storage and transfer of information over some prior analog alternative (TV, radio, 2G mobile phones etc), or use digital technology to replace previous chemical or physical processes cameras, copying/printing etc). The ubiquity of the networked computer generally allows the output of these products to be stored, perhaps amended and be communicated to others. While a few of the products are completely novel, in that they introduce totally new forms of activity or entertainment, most – such as digital TV, digital radio or the digital camera - represent replacements for existing artifacts, some of which have existed for a considerable period. These replacements typically offer a potentially fatal challenge to their predecessors: not merely does digital technology generally bring superiority in the performance of the product's primary tasks, it usually adds many functions that were hitherto unattainable often with the additional benefits of communicability. Furthermore, the spectacular price decline accompanying the diffusion of digital innovation, another a key characteristic of a GPT, encourages the ultra-rapid adoption of the new products and hence displacement of the old.

The literature emphasizes that the diffusion of a GPT generates widespread opportunities for entry. Jovanovich & Rousseau (2003) suggest that in general it encourages entry from young firms able to develop the new technology and challenge existing producers whose capabilities are correspondingly degraded. However, at least two additional and partially countervailing arguments may be raised: First, to the extent that very substantial potential markets are created for consumer product innovations, the opportunities generated might be expected to be particularly attractive to large high-tech firms. These typically possess both the R&D capacity to develop the new technology and the national or global brand name to generate the sales volumes necessary to permit returns to such R&D efforts. Thus we might expect induced innovations to encourage large firms to enter markets they have historically shunned. Second, unlike prior GPTs, digital technology has developed in an era where collaborative arrangements are commonplace. These may cover any aspect of production, from technology sharing, joint development of products etc. through to the outsourcing of manufacture and even the production of "badged" models for sellers with minimal technological involvement in the area. Such collaborations might be expected to circumvent traditional resource constraints. Collaborations could simultaneously make it easier for outsiders to enter new markets and facilitate insiders accessing those new resources necessary to maintain their market presence by offering the new digital version of their product.

This paper explores the role of prior experience in the early evolution of the digital camera (DC) market. The DC is typical of the range of digital products spawned in the

ICT revolution. The global market grew from a few thousand units in the mid-1990s to exceed 30m units by 2003. There have been simultaneous spectacular changes in quality and price, with the average resolution, or picture quality, increasing fivefold or so and the price falling sharply[iii]. Each of these developments has been particularly driven by declining costs of major components, especially the key *sensor*, or semiconductor, that captures the image. Accompanying the rapid growth of the market, the traditional photographic equipment manufacturers, many of whom had been in the industry for generations, were joined by a large influx of newcomers from industries including video and TV, other electronic products, ICT, communications etc. However, as in other high-tech markets, the DC is exhibiting a contraction in the early stages of its product life cycle. Within a few years of widespread entry we have observed the emergence of relatively high levels of market concentration and a considerable shakeout of producers.

This paper looks at the impact of past experience on the early evolution of the DC market. It explores the impact of industry experience, firm size and country of origin on survival and sales among 81 initial entrants to the consumer point-and-shoot DC market. It finds that prior experience in the traditional industry remains a major determinant of both survival and subsequent sales performance in the new product market. However, it also reports that experience in the principal related application of the new technology raises performance, as does, less robustly, reported prior R&D on the specific product. Firm size *per se* does not appear to determine success; although size is beneficial conditional upon specific experience.

The paper is organized as follows: Section 2 looks at the role of capabilities in shaping entry and the challenges to this process during a period of widespread product innovation under a GPT. Section 3 presents a brief background on the development of the consumer DC. Section 4 outlines the data and the empirical results. A brief conclusion follows.

2. Capabilities, Experience and Entry: With Sequential and Simultaneous Innovations

The literature on entry into new product markets has established three key stylized facts: First, what turn out to be important product innovations typically attract high rates of entry soon after their initial appearance. Second, many of these entrants will disappear in a subsequent shake-out. And third, among the successful entrants and/or the survivors of the shake-out period there will be an over-representation of those who possessed prior related experience. These may be explored in more detail:

While patents are undoubtedly important in explaining the success and failure of individual producers, in general they do not appear to inhibit entry except in a small number of industries, such as pharmaceuticals, where the full product specification might be considered novel. Even here, as Klepper and Simons (1997) show in the case of penicillin, patenting is unlikely to extend protection to other compounds in the class. On the contrary, those innovations that subsequently prove to be commercially important (cars, tires, personal computers etc) generally attract rapid entry from many new and established firms alike that anticipate their potential. Geroski (2003) suggests that entry rates are high for young product markets because initial participants expend few resources on the deployment of strategic entry barriers.

Geroski (1995), surveying the empirical evidence on market entry, concluded that while new entry might be relatively easy, sustaining that presence was more difficult. It is clear that the initial entry burst typically gives way to a shakeout; although there are alternative explanations for the nature and timing of this phenomenon. Jovanovich (1982) presents a general model of entry in which entrants are initially ignorant of their own cost structure. They learn this with the experience of producing and many subsequently exit when it becomes apparent that price will be lower than any feasible marginal cost. Similarly, Jovanovich and MacDonald (1994) distinguish the basic innovation that creates the market from its subsequent refinements. In their model refinement innovations are more likely to come from the initial entrants. Some of these refinements will become dominant, leaving non-adopters unprofitable and having to exit. Utterback and Suraez (1993) characterize a similar process in which new products ultimately develop a dominant design, at which point product innovation becomes incremental and an emphasis on process innovation and cost reduction triggers exits. Klepper (1996) also arrives at a similar endpoint with a model that incorporates increasing returns to R&D. Here successful initial entrants are able to appropriate the benefits of process R&D across greater outputs putting pressure on newcomers and/or less successful rivals.

Penrose (1959) and Richardson (1972) initially described the process by which the firm's opportunity set became shaped by its accumulated resource bundle. Penrose explained diversifying growth – ie entry into new (to the firm) markets - as a means of more fully utilizing the asset bundle under management control. Richardson explicitly considered the impact of such firm heterogeneity on the diffusion of new processes and products, arguing that inter-firm differences in resources would impact on the incentive to adopt new innovations. The resource-based view (RBV) of the firm (see Wernerfelt (1984), Barney (1991) etc.) has developed and built upon these insights. The RBV presents the firm as a bundle of resources and capabilities under the semi-permanent control of managers. The latter's key strategic function is to secure a competitive advantage by selecting the markets in which the firm operates so as to make optimal use of that bundle. Where the relevant required resources possessed by the firm are difficult for rivals to replicate, any such advantage is likely to be sustainable, and in general the hardest resources to replicate are those acquired by firm-specific experience.

Empirical research has broadly supported this contention by suggesting that the key resources determining both the probability of a firm's entry to a new market and the likelihood of success conditional upon entry are the capabilities acquired as a result of past experience in related markets. Scott Morton (1991) considers entry to pharmaceutical product sub-markets as currently successful compounds become ex-patent. She shows that prior technological experience with the compound class, delivery system etc. determines which generic sub-market a manufacturer will choose to enter. Nerkar and Roberts (2004), using ex-patent and *de novo* pharmaceutical products show that prior technological and product-market experience generally turn out to be significant predictors of initial sales of the product. Similarly, Klepper and Simons (2000) show that prior experience with radio technology increased the likelihood of entry into black and white TV receiver manufacture in the 1950s which in turn increased the probability of entering color TV manufacture in the 1970s. They also report that conditional upon entry, firms with the relevant prior experience showed a lower hazard as shakeout occurred in each case. Other support for the importance of experience in determining subsequent performance comes from Michell (1991) and Carroll et al (1996) who report similar beneficial effects for entrants in the contrasting diagnostic imaging and early US auto industries.

The concept of a general purpose technology has been advanced to explain the historical phenomenon of sustained periods of abnormally high economic growth each characterized by a numerous linked innovations which impact on output and productivity growth. In analyses of the classic industrial revolution of the eighteenth and nineteenth centuries, GPTs have been identified with the introduction of water- and steam-power, respectively. More recently, electrification and the introduction of ICT have been widely considered to play a similar role. Following Bresnahan and Trajtenberg (1996) a *general purpose* technology should possess three requirements: First, it should be *pervasive* in the sense that it will spread to most sectors. Second, it should display *improvement* over time, thus lowering costs for its users. And third, it should be *innovation spawning* in the sense that the technology should make it easier to invent and produce new products and processes that in turn impact upon output and/or productivity growth.

The mix of innovations induced by a GPT clearly depends on both the technology itself and the level of inchoate consumer demand, itself dependent on the level of disposable incomes. Thus water- and steam-power were very largely associated with process innovations; although they also generated some product innovations, most obviously mass rapid transit in the case of railroads. By contrast, electrification spawned a range of new consumer durable products and the ICT revolution has arguably made a greater impact via the generation of product innovations than it has had on conventional productivity via its process innovations[iv].

A number of arguments may be advanced why innovations induced by the diffusion of a GPT may be subject to rather different entry patterns:

First, as noted above, the literature (eg Jovanovich and Rousseau, 2003) stresses that a GPT, in advancing a new technology, might be expected to degrade older capabilities. In general the literature predicts entry by new firms and an increase in control changes, including mergers, divestments etc., among older firms as assets are reconfigured to meet the new requirements.

Second, in comparison with previous GPTs, digital technology has developed in an environment where there exist many large firms with R&D strengths and, in many cases, global brands. Some of these firms clearly possess experience in related uses of the technology, even where they lack prior technological or market experience in the specific industry context. Furthermore, they may possess sufficient resources to make a near simultaneous entry into multiple product markets[v]. The possession of an established brand might be expected to be advantageous in entering any new market where there is inevitable consumer uncertainly attaching to the new product. Furthermore, where consumer products are sold through regular retail outlets and not specialty stores, the possession of an established brand name is likely to be beneficial in securing shelf space and hence early sales.

Third, collaborative arrangements have become commonplace in the development and production of new digital products. These extend from technology pooling and joint ventures in product development, through to outsourcing etc. Collaboration offers opportunities for existing industry members and newcomers alike to circumvent strategic resource constraints

This paper looks at entry to a new digital product market to explore the relative importance of new and traditional capabilities. The industry chosen is digital cameras which, it will be suggested is typical of the wave of product innovations being induced by the diffusion of the ICT general-purpose technology.

3. The Evolution of the Market for Consumer Digital Cameras

In a digital camera the traditional mechanical and chemical photographic method of image capture is replaced by a sensor containing several million receptors or pixels. These record the image as a set of components that is then digitalized for storage and onward transmission. The sensor is based on a semiconductor, usually a charge coupling device (CCD) but sometimes, normally in top and bottom end applications, a complementary metal oxide semiconductor (CMOS). The former device is more costly to fabricate, much more power-greedy but it does have a higher signal-to-noise ratio and is easier to miniaturize. Sensor capacity, in terms of megapixells, and prices have broadly followed Moore's Law[vi] permitting a spectacular improvement in digital camera picture quality and a correspondingly impressive fall in both the absolute and quality-adjusted price of DCs. Furthermore, the digital technology allows the DC user many functions relating to the capture, enhancement and transmission of images that are impossible with traditional photographic technology.

The global market for consumer DCs grew from a few thousand units in 1996 to 27.97m units in 2002 (IDC 2003). Before 1996 there was no real market for consumer point-and-shoot DCs at all: the only digital cameras available were very highly priced models suitable for fixed use in studios or in photojournalism. The timing of this take-off appears to be linked to three key factors: First, on the supply side a solution was needed to the technical problems of moving from video technology to develop a high quality still image capture process, capable of incorporation in a robust point-and-shoot format with an affordable level of resolution. This was being investigated during the 1980s, with some ultra-high price specialist models available from the early1990s. The market really developed when the first sub-$1000 model made the DC affordable for enthusiastic amateurs. Second, as production developed, learning economies brought rapid cost declines over the product life of individual CCD/CMOS semiconductors and the rapid replacement of each generation of sensor by a higher capacity successor. This sustained the sharp quality-adjusted price fall noted earlier. Finally, on the demand side the take-off in DC sales was predicated on the prior diffusion of personal computers, the stock of which reached 109m (50m home PCs) in the US alone in 1997 (Freeman and Louca, 2001 p314).

While the traditional camera as a consumer product goes back to the nineteenth century, the industry had experienced a bifurcation over the three decades that preceded the introduction of consumer digital camera. Windrum and Frenken (2003) suggest that it had coalesced around two dominant designs in the sense of Utterback and Surez(1993). These were the cheap, easy-to-use compact design that was pioneered initially by the Kodak 126 and the more expensive, "serious hobbyist" single lens reflex (SLR). The former, embodying a separate lens and viewfinder system was intended for the “snapper” who wanted to record events without investing much effort in learning photographic techniques. The SLR, in which the image formed by the lens is observed directly through the lens using a penta-prism, offered superior quality to those prepared to invest money and effort into acquiring one and learning how to use it. European camera makers had initially developed the SLR out of the 35mm camera, but Japanese manufacturers (Canon, Minolta, Asahi-Pentax and Nikon), who were offering greater functionality at keen prices, increasingly dominated it (Windrum and Frenken, 2003). Some larger manufacturers produced models in each design, while other concentrated on one or the other.

Once consumer DCs started to sell in numbers from 1995/96, entrants appeared from several industries including video and TV. The video camera industry had remained largely distinct from traditional still photography. It had developed in the 1980s as the VCR emerged as a product that permitted both home movie-watching and the time-shifting of TV programs. This market had been populated by diversifying TV receiver manufacturers and entry by general electronics firms. Some video camera manufacturers, especially Sony, were working from the late 1980s to develop still DCs. However, entry to the DC market also came from ICT firms, general consumer electronics manufacturers, office products manufacturers and from other industries including communications and games and toys. Early entrants also came from the traditional camera makers, some of whom (Kodak, Agfa, Canon etc) had been investing in digital R&D since the start of the decade and some of whom entered the market once they appreciated the extent of the threat to their core business[vii].

The DC market was perhaps particularly attractive to entrants because of the relative lack of bandwagon effects (Rohlfs, 2001). The DC is predicated on connectivity to a computer and obviously requires both appropriate software and output ports. However, these are fairly non-specific. There are no obvious network effects generating positive feedback in the market (Shapiro and Varian, 1999) in the manner of numerous other digital products including games and software products. Of course, early mover advantages may still accrue in a young market as a result of reputation effects and retailers’ unwillingness to stock those other than the leading brands.

The effect of the DC as drastic innovation appears to have been to challenge the two dominant designs described above. Not merely did entrants offer a substantial range of compact and SLR models with digital technology, but other forms developed to exploit or promote the new technology. These included the ultra-compact model, the cheap novelty camera or game accompaniment, based on the VGA standard and the "DC back", essentially a kit to allow a traditional camera to be adapted to digital technology. Some of these designs proved to be unsuccessful. The low-quality VGA-based products and the "DC back" were undermined by CCD/CMOS sensor cost falls that dramatically reduced the prices of higher resolution DCs.

4 Survival and Performance among Entrants to an Induced-Innovation Market: Hypotheses

In the literature reviewed above it is clear that when a more or less randomly generated product innovation impacts upon an established industry, we expect to observe firms with industry experience being differentially successful in operating in the new product markets. However, with GPT-induced innovation we expect three additional sources of new entrants: first, firms outside the industry but with experience in the new GPT; second, following Jovanovich and Rousseau (2003), start-up and other smaller firms able to innovate with the new technology; and third, large firms, irrespective of industry background, who are able to use their established brand-names to sell in the new market. This leads us to the following hypotheses:

Hypothesis 1: Capabilities derived through experience in the traditional industry continue to exert a positive impact in survival/performance in the new product market; but alongside:

Hypothesis 2: Capabilities derived through experience outside the specific industry but gained from working with the GPT exert a positive impact on the entrants' survival/performance in the new product market.

We have no *a priori* belief about whether traditional industry experience will dominate related GPT experience in explaining post-entry performance. However, Nerkar and

Roberts (2004) have recently reported that prior R&D in the product area ("proximal technological experience", in their terms[viii]) is a significant predictor of market performance. In the digital camera case, prior R&D directed towards the development of a viable point-and-shoot consumer model was undertaken by traditional photographic manufacturers, such as Kodak, and video/electronics manufacturers, such as Sony. Therefore a subset of firms from what we conjecture to be the two best-placed industries from which to enter the DC market had engaged in pioneer product development. Thus it is conjectured:

Hypothesis 3: Pre-1996 experience in building prototype consumer DCs and/or professional studio or photo-journalism DCs will improve the firm's subsequent performance in the consumer DC market.

There are no unambiguous priors suggesting a monotonic relationship between firm size and the firm's likelihood of success on entering a GPT induced innovation. Large firms clearly possess advantages in obtaining those resources necessary to develop new models in a rapidly evolving technology. Furthermore, the possession of a major national or global brand is potentially advantageous in generating the sales volumes necessary to recover R&D costs. In which context it may be observed that many of the new markets for digital products, including those for cameras and personal computers, have experienced intense price competition raising obvious difficulties for sellers recovering sunk costs. However, merely because large firms find it relatively easier to enter new markets than smaller firms does not itself imply they will remain there. For example, in the USA many electrical and electronics contractors entered the computer business in the 1970s and 1980s and exited relatively quickly. Indeed multiple market entry by large firms may be considered a form of search process in which diversifying firms seek business opportunities. It was also noted above that the GPT literature sees the innovations associated with a new generic technology as a major driver of Schumpeterian "creative destruction", in as much as they degrade existing capabilities and market positions. In the turbulence that accompanies such an innovation it has been suggested that innovative smaller firms prosper.

The empirical evidence on new market entry broadly supports the contention that size has a beneficial effect on both survival and subsequent sales. Klepper and Simons

(2000), for example, report that size on entry to the TV receiver entry lowers the exit hazard rate and impacts positively on future sales; although the extent of this influence declines with time elapsed since entry. However, the empirical literature is not especially informative in delineating the specific benefits conferred by size: Cottrell and Nault (2005) report diseconomies of scope in the survival of products introduced by by software companies

While we have no strong priors on the overall influence of size, it does seem likely that some specialization will occur. Large firms, with strong brand names and the marketing resources that typically accompany these, seem more likely to succeed in becoming major producers of the new product. This appears especially likely for those new consumer products, such as DCs, sold through general retail outlets where a limited brand range may be stocked. However, precisely because entry may be relatively easy for a large firm at the outset of a new product innovation, exit will also be relatively costless. Consequently, we anticipate that firm size will play a lesser role in explaining survival than it does in explaining subsequent sales success. Conversely, smaller firms tend to occupy more specialized niches where lower sales volumes may deter large-scale production. Therefore it is conjectured that smaller entrants may perform relatively better as survivors than they do in subsequent overall sales. This suggests:

Hypothesis 4a: Among market entrants, firm size on entry will be positively related to subsequent sales performance; and

Hypothesis 4b: The firm's size on market entry will be weakly (positively) related, if at all, to its subsequent survival in that market

The development of the DC market has coincided with the rapid advance of globalization. Furthermore, intense price competition among the producers has driven a search for economies that has encouraged European Japanese and US manufacturers to outsource camera production to Taiwan, China and other Asian countries (Gartner, 2002). This reflects lower labor costs in these countries. Furthermore, whether this outsourcing is direct to Asian camera-makers or occurs via joint ventures, and both modes are commonplace, the shift in production towards, especially, Taiwanese and

Chinese producers might be expected to transfer technology to these manufacturers occurs. Therefore we conjecture:

Hypothesis 5: Country of firm origin will impact on both the firm's survival and and its performance in the new market such that early entrants from Asia, outside Japan, will show a *ceteris paribus* advantage over rivals from Europe, Japan and the USA.

5 Data: Sources and Characteristics

The basic sample comprised 91 firms that were identified by www.digicamhistory, supplemented by additional DC website archives[ix], as being involved in selling consumer DCs during the entry years 1996 and 1997. Incomplete identification problems and/or missing data reduced this to a usable sample of 81 entrants for the empirical analysis. The performance of these entrants was assessed in two ways:

First global sales in 2002 were obtained or estimated from IDC (2003). This publication gave the unit sales figures for seven leading sellers accounting for 88.7% of the global point-and-shoot market shipments in 2002. European and Asian markets were not as heavily concentrated as the US market and sales data were available on a further five large sellers outside the top seven. These were assumed each to have a share of the residual global sales based on their proportion of the residual of the European market not supplied by the 7 global leaders. Finally, those surviving 26 sellers too small to secure coverage in IDC (2003) and for whom no global data were available, were assumed to share equally the approximately one percent of the global market not supplied by the leading 12. The resulting highly skewed sales variable was incorporated as **LnSales** after taking its natural logarithm[x].

An alternative performance variable (**Surv1**) was constructed equal to one for those 38 (47%) of entrants that had survived the initial shake-out and were still operating in the DC market in 2003. In some cases it was apparent that although selling DCs these firms had no production facilities and were essentially marketing "badged" versions of others' products. Eliminating these firms from the survivor list gave 35 (32%) entrants still producing and these were coded as an alternative survival variable (**Surv2**).

Firm size presented considerable measurement difficulties. First, while firm size is easily measured by input or output data in countries such as the US or UK, it is a more ambiguous concept in parts of Asia where industrial groups dominate. Second, detailed size data was simply incomplete for the set of entrants, with particular gaps inevitably associated with the smaller entrants. Therefore we followed Klepper and Simons (2000) in using binary variables to split the sample into broad size classes. These were **Large** firms, defined as having assets greater than US$400m in 1996/7. **Medium** firms defined as having assets between $20m and $400m and **Small** firms with assets apparently below $20m.

It was noted above that some firms were trying to solve the technical problems of designing an affordable consumer DC before 1996. A binary variable (**PriorR&D**) was created for those firms identified by www.digicamhistory, supplemented by other digital camera history sites, as having developed a marketed or prototype DC in the years prior to 1996. It is notable that all of these firms were located in either the tradition photographic industry (**Photo**) or the TV and video industry (**Video**).

In addition to the **Photo** and **Video** industries, entrants were identified as coming from software and ICT (**Sict**), office products (**Offic**), with smaller numbers from toys and games, other electronics, batteries and components and other unidentified industries. These were lumped together into a general reference category when industry dummies were introduced to the regressions. If a firm was operating in two or more industries which included **Photo** and/or **Video** it was assigned to the latter, as appropriate. Thus, for example, a general electronics manufacturer that was also active in TV or VCR manufacture was assigned to **Video**.

Finally, a series of country of origin binary variables was created for the **US**, **Japan**, **Europe**, **China** and **Other Asian** manufacturers, respectively. Even during the short commercial history of the consumer DC there has been a major shift in production from Japan, Europe and the USA to China and other Asian countries. While this appears to be predominantly the consequence of outsourcing by manufacturers from the former countries, it seemed likely that the underlying cause, essentially the drive to cut labor costs in a product experiencing intense price competition, might be expected to confer advantages or manufacturers already located in countries such as Taiwan and China.

Section 6: Results

The performance and survival equations were estimated and the results are given in Tables 2 and 3. It is immediately apparent that entrant performance, measured as **Ln(Sales)** in 2002 is strongly influenced by relevant industry experience prior to the development of the consumer DC market in 1996. This extends to **Photo,** the traditional camera-making industry, and **Video,** the video and TV manufacturing industry that was the proximate source of the digital imaging technology to be incorporated in DCs. **Office products,** which included photocopiers, also displayed a robust positive and significant effect in the sales performance equations. However, software and ICT (**Sofict)** the other obvious potential industry source of relevant expertise, was uniformly insignificant. A very similar pattern of industry effects is seen in Table 3 for the survival equations; although the coefficients for the three significant industries are of very similar magnitude.

Obvious care is needed in the treatment of the **PriorR&D** variable since it is a subset of the union of the **Photo** and **Video** variables and, as such, collinear with each. Moreover, the number of non-zero cases (21) is relatively small. Nonetheless it attracts the expected positive sign in all estimations, but is only significant in the survival equations.

There is no evidence of an effect of firm size *per se* in that neither **Large** nor **Small** carried a significant coefficient against the omitted reference category (**Medium**). Furthermore, there was no support for our conjecture that size on entry would be more important in explaining entrants' subsequent sales than it would be in explaining mere survival. However, when the size variables were interacted with the two principal industry experience variables there was clear evidence of conditional size effects. In the case of **Photo** there was a clear hierarchy of effects with the Large dominating the Medium which in turn dominated the small, suggesting that among entrants to the DC market from a traditional photographic industry background, size was a significant predictor of future success. The interaction terms were inappropriate for the survival model because of the perfect correspondences between outcomes and industry*size interactions. Size interactions with **Video** were insignificant.

The country of origin dummies carried the expected pattern of coefficients, with Europe, Japan and the USA showing negative effects relative to the Chinese reference category. However, the coefficients were individually (and jointly) insignificant. It appeared that any cost disadvantage experienced by firms originating the former countries could be offset by outsourcing.

7 Conclusion: Plus ca change….

A central feature of the notion of a general purpose technology as a driver of growth is that it induces the near-simultaneous production of a rush of related innovations across a wide range of industries. The contemporary flood of digital innovations as replacements for earlier analog or electrical/mechanical products, as part of the ICT revolution, appears a good example of this process. It had been widely suggested that such a development is highly disruptive of the established order and encourages new entrants to displace traditional producers as new resources and capabilities are required to introduce digital technology and some old ones become redundant. The digital camera appeared to be a highly suitable case to explore this. As with other digital products it has largely replaced a long-established traditional alternative in a very short interval in a market that has seen widespread entry from numerous industries.

However, our results suggest that the extent to which traditional resources and capabilities have been replaced should not be exaggerated. Among those entering the entirely new market for consumer DCs at its inception in 1996 and 1997, prior experience in traditional camera manufacture remains a major determinant of both subsequent sales success and survival. If some established resources and capabilities were degraded, as appears likely, this suggests that compensating features such as reputation, sales organization etc proved useful in the context of a new – and therefore uncertain – product. However, entrants with video technology experience but from outside the traditional camera sector also exhibited significantly higher rates of survival and sales performance. That is new (to still camera manufacture) capabilities were beneficial. But these appear to have come from activities closely related to the specific application of the new technology – ie video/tv and, less robustly, office products – rather that being generic ICT capabilities.

Prior specific research on digital cameras certainly appeared to aid survival, but its impact on sales performance was insignificant. This somewhat weak result stands in some contrast to Nerkar and Roberts (2004) who found prior patenting to be a major determinant of success in pharmaceuticals. This may reflect the comparative ease of technology acquisition in digital products where key components such as the CCD/CMOS sensors are relatively widely available and where collaborative arrangements to develop and produce new products are commonplace.

The GPT literature had also suggested that new entry by smaller firms was likely. However, it had been noted that the advent of digital technology, and the promise of very large markets for the new products it created, would also be attractive to large established firms. In the event size did not appear to be a general determinant of success. However, among entrants from a traditional photography background, size did matter with the performance of large firms dominating that of medium-sized firms who in turn dominated their smaller rivals.

The paper began by noting that considerable support for the view that resources/capabilities matter in determining entry outcomes has been obtained in the growing empirical literature on new product market entry. This has broadly established that prior industry experience, both technological and market, is the major predictor of success following entry to a new product market. It was conjectured here that the diffusion of a GPT, involving as it does the simultaneous development of numerous new product markets, might challenge this received view. This appeared likely insofar as traditional capabilities were degraded by comparison with generic ones associated with the new technology and additional attributes, including possession of a global brand, assumed greater value. However if, as argued here, the DC is representative of other induced innovations in the digital revolution, the diffusion of a GPT does not appear to fundamentally alter the received view. Rather it appears to make a highly specific widening of the set of industries from which successful new entrants are likely to emerge.

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Table 1: Variable Summary Statistics

Variable	N	Mean	Std, Dev	Min.	Max.
LnSales	81	-12.449	9.017	-20.72	1.711
Surv1	81	.457	-	0	1
Surv2	81	.420	-	0	1
Photo	81	.309	-	0	1
Video	81	.333	-	0	1
Offic	81	.062	-	0	1
Sict	81	.222	-	0	1
PriorR&D	81	.259	-	0	1
Large	81	.383	-	0	1
Medium	81	.407	-	0	1
Small	81	.210	-	0	1
Europe	81	.358	-	0	1
Japan	81	.346	-	0	1
USA	81	.136	-	0	1
Other Asia	81	.123	-	0	1
China	81	.037	-	0	1

Table 1: Determinants of Sales: OLS Estimates with Robust Standard Errors

	(1)	(2)	(3)	(4)
	LnSales	LnSales	LnSales	LnSales
PriorR&D	4.406	3.207		
	(1.46)	(1.26)		
Photo	10.224		12.445	
	(3.96)**		(6.25)**	
Video	4.888		5.566	
	(2.39)*		(2.73)**	
Offic	7.552	7.513	6.825	7.577
	(1.70)	(2.02)*	(1.45)	(2.03)*
Sofict	2.231	1.95	3.283	2.174
	(0.72)	(0.69)	(1.08)	(0.77)
Large	0.266		1.102	
	(0.12)		(0.49)	
Small	0.264		-0.531	
	(0.08)		(0.17)	
USA	-4.128	-4.115	-2.789	-3.221
	(1.31)	(0.84)	(1.00)	(0.66)
Japan	-1.916	-1.719	0.245	-0.241
	(0.66)	(0.35)	(0.12)	(0.05)
Europe	-2.585	-2.02	-1.928	-1.477
	(0.71)	(0.41)	(0.59)	(0.30)
Other Asia	-1.825	-0.878	-1.355	-0.454
	(0.54)	(0.16)	(0.43)	(0.08)
Large*photo		14.076		16.443
		(3.76)**		(5.05)**
Med*photo		9.423		10.557
		(3.05)**		(3.56)**
Small*photo		-3.515		-3.183
		(0.43)		(0.39)
Large*video		3.911		4.576
		(1.38)		(1.63)
Med*video		5.144		5.27
		(1.38)		(1.41)
Small*video		2.602		2.406
		(0.60)		(0.55)
Constant	-16.864	-16.33	-18.345	-17.086
	(6.67)**	(3.42)**	(10.59)**	(3.59)**
N	82	82	82	82
R-squared	0.381	0.422	0.356	0.409

Robust t statistics in parentheses
*significant at 5%; ** significant at 1%

Table 2: Determinants of Survival: Logit Estimates

	(1)	(2)	(3)	(4)
	Surv1	Surv2	Surv1	Surv2
PriorR&D	1.595	1.839		
	(1.96)*	(2.25)*		
Photo	2.445	1.853	3.049	2.574
	(2.30)*	(1.75)	(3.13)**	(2.69)**
Video	1.844	1.949	1.918	2.016
	(1.78)	(1.86)	(1.99)*	(2.09)*
Offic	2.677	2.968	2.207	2.376
	(2.05)*	(2.18)*	-1.81	-1.88
Sofict	0.585	0.886	0.864	1.179
	(0.53)	(0.78)	(0.80)	(1.06
Large	-0.230	-0.458	0.165	0.007
	(0.29)	(0.58)	(0.22)	(0.01)
small	0.130	0.355	-0.129	0.019
	(0.14)	(0.39)	(0.14)	(0.02)
USA	-1.862	-2.776	-1.462	-2.211
	(1.14)	(1.75)	(0.84)	(1.34)
Japan	-1.714	-1.973	-1.008	-1.123
	(1.03)	(1.24)	(0.58)	(0.69)
Europe	-0.959	-1.463	-0.833	-1.275
	(0.58)	(0.94)	(0.47)	(0.77)
Other	-0.694	-0.996	-0.592	-0.855
Asia	(0.42)	(0.64)	(0.33)	(0.51)
Constant	-0.772	-0.440	-1.101	-0.843
	(0.50)	(0.30)	(0.67)	(0.54)
N	82	82	82	82
Pseudo R2	0.257	0.246	0.221	0.196
LR chi2	29.13	27.52	24.97	21.92

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

References

[i] See the debate between Barney (2001) and Priem and Butler (2001).
[ii] Lockett and Thompson (2001) present a review of the literature on the importance of acquired resources in explaining subsequent firm behavior and performance.
[iii] Thompson (2005) calculated that the *quality-adjusted* price of digital cameras on the US market fell by one and a half percent per month between January 1996 and December 2003.
[iv] The computer revolution was notoriously slow to reveal itself in productivity studies, giving rise to a considerable debate over the so-called "IT paradox". This literature is reviewed in Haynes and Thompson (2000).
[v] In the parallel case of entry following deregulation, where again multiple opportunities for entry may present themselves in a simultaneous fashion, firm size typically facilitates positively on the decision to enter: see, for example, Ingham and Thompson (1994).
[vi] The empirical observation that (initially) semiconductor capacity and (more latterly) semiconductor costs per unit of capacity tended to double and halve, respectively, every 18 months: see
[vii] The "replacement effect" [Besanko et al (2003)], which ordinarily generates a greater profit incentive for outsiders to pioneer an innovation, was here countered by the obvious threat to the traditional photographic firms' incomes from film sales. By contrast, new entrants from an office products or electronics background could look to additional benefits from printer and storage device sales, respectively.
[viii] In their pharmaceutical context this is defined in terms of prior patent count in the same therapeutic area: see Nerkar and Roberts (2004) p 787.
[ix] Including www.dpreview.com
[x] The 43 entrants in 1996/97 that had ceased activity in the market and thus had zero sales were assigned a very small positive constant to allow the natural logarithm to be defined.