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Paul Windrum

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MERIT – Maastricht Economic Research Institute on Innovation and Technology

PO Box 616
6200 MD Maastricht
The Netherlands
T: +31 43 3883875
F: +31 43 3884905

http://www.merit.unimaas.nl
e-mail:secr-merit@merit.unimaas.nl

International Institute of Infonomics

c/o Maastricht University
PO Box 616
6200 MD Maastricht
The Netherlands
T: +31 43 388 3875
F: +31 45 388 4905

http://www.infonomics.nl
e-mail: secr@infonomics.nl

New cycles of innovation in a mature industry: the camera industry 1955-1974.

Paul Windrum
Manchester Metropolitan University Business School, UK/
MERIT, University of Maastricht, NL*
p.windrum@mmu.ac.uk

Abstract

The paper examines the dynamics of the amateur camera market – a mature industry - in the period 1955-1974. The case study raises a number of important issues for innovation management in mature industries characterised by heterogeneous preferences and heterogeneous product designs. First, it is possible for radically new product designs to be introduced in mature industries. These can lead to a further bifurcation of the industry into an increasing number of market niches. Second, this provides an opportunity for new entrants to overcome the first mover advantages of dominant firms, and, indeed, displace these dominant firms. Third, incremental innovations that are introduced across the alternative new product designs may be adopted by some user groups but not by others. This can turn conventional managerial strategy on its head, with incremental product innovations first being adopted in low-priced, rather than high-priced, goods.

JEL: L10; L60

Key words: product life cycle, innovation, market niches, cameras, photography.

* Paul Windrum is an associate of MERIT, University of Maastricht.

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1. The innovation life cycle and alternative explanative models

According to Klepper (1996), competing explanations of innovation life cycles need to account for six empirical observations. First, the diversity of competing versions of the product and the number of major product innovations reach a peak in the early phases of the industry life cycle and then fall over time. This pattern is associated with a rise and then fall of new market entrants. Second, at the beginning of the industry, the number of entrants may rise over time or else peak at the start of the industry and then decline over time. In both cases, the number of entrants eventually becomes small. Third, over time, producers devote increasing effort to process innovation and less to product innovation. Fourth, during the period of growth in the number of producers, the most recent entrants account for a disproportionate share of product innovations. Fifth, the number of producers grows initially and then reaches a peak, after which it declines steadily despite continued growth in industry output. Sixth, the rate of change of the market shares of the largest firms slows and the leadership of the industry stabilises.

A number of competing theories have sought to explain these empirical observations. Let us consider two of the most widely cited of these, the Abernathy-Utterback model and the Klepper model. The Abernathy-Utterback model is the oldest explanation of the innovation life cycle, dating back to their seminal 1975 paper (Abernathy and Utterback, 1975). At its theoretical core lies the dominant design concept. In the earliest phase of the life cycle, an industry is characterised by considerable uncertainty. Not only is there uncertainty regarding consumer tastes and the potential size of the market for the new good/service, there is also uncertainty regarding the technical constraints that exist and the appropriateness of the different alterative technological solutions. This technical uncertainty stimulates novelty and experimentation on the part of competing firms that are attracted to the high returns associated with new technology goods/services. The number of new start-ups and market entrants is high. Further, these companies, in the face of technical and market uncertainty, typically develop rival designs that represent very different ideas and solutions to technical problems.

Through market competition, the number of rival product variants declines. According to the Abernathy-Utterback model, the first phase of the life cycle ends with market convergence to a single design, or 'dominant design'. This dominant design changes the competitive landscape. First, an industry shake-out occurs. First-mover advantages lie with the firms(s) that developed the dominant design. If possible, rival firms that developed initially alternative designs must switch their production of the dominant design. If not, they will be squeezed out of the market. Second, the dominant design is a design that is stable enough - i.e. profitable and technically feasible - to support a significant volume of production. The focus of innovation switches therefore shifts in the next phase of the life cycle to process innovation.

The switch in the locus of competitive advantage, from product to process innovation, focuses on cost/price differentiation between the remaining firms producing the dominant design. The drive to exploit economies of scale and expand market share encourages radical experimentation with new and alternative production technologies. According to the Abernathy-Utterback model, a second industry shake-out occurs as those firms that are relatively unsuccessful in process innovation are squeezed out of the market by their more successful rivals. The second phase of the life cycle ends with the emergence of a 'dominant process technology' by which the dominant design is produced. In the Abernathy-Utterback model, the third and final phase of the innovation life cycle is characterised by market stability with the leading firms maintaining their position through incremental innovation focused on the gradual improvement of the standardised product-process nexus.

A very different explanation of the innovation life cycle is provided by Klepper's R&D capacity model. In this model, the dynamics of competition are driven by the process R&D capacities of firms rather than the emergence of a dominant design through product innovation and competition. Indeed, Klepper's model assumes that a 'standard product' exists from the outset and seeks to explain all six empirical observations through process R&D. The model assumes that the returns to process R&D are a direct function of firm size. As firms grow, they increase their expenditure on process R&D. In addition, firms' costs are assumed to be solely dependent on the level of process R&D conducted in each period: firms are price-takers who offer their output at average market price. However, since average unit costs differ across firms according to their volume of sales, marginal profits differ according to market share.

Turning to demand, consumer preferences are assumed to be homogeneous with downward sloping demand curves. In the absence of product innovation, consumers select the firm they purchase from according to a stochastic process that is based on current market share. This establishes a positive feedback between profit, expenditure on process R&D, costs, future revenue streams and future market share. Hence, the ultimate driver of competition in the Klepper model is 'learning to do (process) R&D'. Established firms with a past record of success, reflected in high market shares, are able to devote higher levels of spending towards process R&D which enables them to produce the standard product at lower unit costs than their less successful rivals. This further raises competitiveness and profits, providing the funds for further investment in process R&D. Over time, these improvements in process technologies raise the minimum efficient scale of production leading to a shake-out of less efficient firms within the industry.

An important, and specific, role is given to new market entrants and incremental innovation in the Klepper model. Through incremental innovation, new firms can enter the industry. A simplifying assumption of the model is that the innovating firm earns a one-period monopoly from the incremental innovation. Thereafter all other firms can costlessly imitate the improved feature(s)[1]. Given homogeneous preferences, and an assumed willingness/ability of the current cohort of consumers to pay a higher price for the improved feature, guarantees demand and revenues for the new market entrant. However, market entry through incremental product innovation becomes increasingly difficult due to increasing start-ups costs (associated with accumulated process innovations) over time. This, Klepper argues, explains why the entry-exit ratio in an industry first increases and then decreases over the course of the innovation life cycle. It also explains, he argues, why the oldest firms have the greatest chance of success. The first-mover advantages of early entrants, based on expertise in process R&D, efficiency, and market size and efficiency advantage, continue to build up over time, placing them in an unassailable position.

Although the Abernathy-Utterback and Klepper models differ regarding the primary drivers of innovation, competitive advantage and industry shake-out, both share a common view regarding the essential phenomenology of the innovation life cycle - i.e. the set of empirical observations that require explanation. However, the camera industry raises serious questions regarding our phenomenological and theoretical understanding of innovation life cycles. According to Klepper's stylised facts of the innovation life cycle, we would expect few or no new market entrants in a mature industry, market shares of the leading firms to be stable, and there to be incremental product and process innovation. With regards to innovation strategy, conventional theory suggests the costs of incremental R&D will initially be recouped by charging higher prices for improved versions of the dominant design/standard product. Later, these improvements will be offered in lower priced versions of dominant design/standard product.

Yet the history of the camera industry challenges each of these stylised facts. First, a new innovation life cycle occurred in the camera industry, a mature industry that had been in existence for nearly a century, between the late 1950s and the mid-1970s. This was associated with a bifurcation of amateur camera market following the introduction of two new and radical product designs: the 126 compact and the single lens reflex (SLR) camera designs. This engendered a sequence of radical product innovations that conventional life cycle theory attribute to infant industries, not mature industries. The process also saw an increase in the number of new entrants, followed by an industry shake-out. Again, this is a pattern that is conventionally associated with infant industries, not mature industries. What is more, the shake-out saw the displacement of dominant firms by new market entrants. Far from having an unassailable market position, dominant U.S. and European firms were displaced by new, Japanese market entrants, who became the new dominant players within just two decades. In addition to the problems posed by this new cycle of radical innovation and market entry-exit, the camera industry poses a further conundrum. Automated exposure mechanisms were first adopted in 126 cameras but not in the more expensive SLR cameras, turning innovation strategy (based on life cycle theory) on its head.

[1] Due to ongoing reduction in price due to process innovation, it is assumed that the price of the standard product will fall in the next period, such that the cost of the innovation borne by the current cohort of consumers.

Understanding the factors that led to this sequence of events in a mature industry is clearly important to our general understanding of innovation life cycles. To this end, the paper examines the historical evolution of the amateur camera market between the mid-1950s and the mid-1970s. Section 2 examines the key factors that saw a new round of radical product innovation in this mature industry. In particular, this highlights the importance of heterogeneous consumer preferences as a key explanatory factor. The success of the 126 compact and SLR camera designs lay in their ability to cater for the needs and preferences of two very different groups of users. Thereafter, section 3 discusses the incremental innovation conundrum posed by the diffusion of automated exposure mechanisms between 1965 and 1974. In order to substantiate the discussion, section 4 empirically tests for distinct market niches, containing user groups with distinct preference sets, and whether the valuations placed on automated exposure differs between these groups.

2. The bifurcation of the amateur camera market

Prior to 1939, the 35mm camera market was dominated by German manufacturers, who developed the viewfinder design. Between 1939 and 1945 supplies of German 35mm cameras ceased, and UK and US manufactures began to produce them. Some were straight copies of Leica and Contax models (e.g. Reid in the UK). However, while the number of U.S. and U.K. manufacturers increased, their cameras were inferior in build and in the quality of the glass lenses used compared to the pre-war German models. Not surprisingly, when production recommenced in the late 1940s, West German manufacturers quickly re-established their dominant position in the U.S. and western Europe. For example, of the 37 viewfinder manufacturers advertised in the 1953 camera guide issued by Amateur Photographer in the UK, 32 were German, 3 were Italian, and 2 were British.

The viewfinder design comprised a large viewfinder set above the taking lens through which the user composed the picture. Being separate from the lens and made of clear glass, the arrangement provided the user with good visibility. The chief drawback of this arrangement, however, is the introduction of parallax error between the scene viewed through the viewfinder and the image captured by the lens. Parallax error becomes increasingly noticeable at short and long distances, prohibiting close-up photography and sports/wildlife photography. Still, the design had advantages in terms of its size and weight compared to other designs that were available at the time, and enabled amateurs to take photographs in the majority of situations. Moreover, high quality glass lenses were widely available, as was the 35mm film format that it used.

The late 1950s/early 1960s saw an important change in the amateur camera market. The introduction of the single lens reflex (SLR) camera and the 126 compact camera saw the amateur market bifurcate into two distinct niches - a division that continues to this day. The success of these two designs lay in the amateur market being comprised not of one, but of two distinct types of users: the 'serious hobbyist' and the 'snapshooter'. The SLR is a sophisticated design that was specifically targeted at the serious hobbyist who enjoys photography as a means of creative and artistic self-expression. The hobbyist values the quality of image reproduction and seeks to control the picture taking process to achieve an intended interpretation of the scene, By contrast, Kodak, when it introduced the first 126 model in 1963, targeted its design at the snapshooter. Snapshooters are infrequent users of camera equipment who typically use it to record key events such as holidays, birthdays and weddings. The snapshooter wishes to record an image with a camera that makes the picture taking process as easy as possible. (S)he is not interested in investing time and energy in learning how to improve their picture taking skills or about the mechanics of cameras. The success of the SLR and the compact camera lay in their designers recognising and catering for these distinctions within each of the respective designs.

While very different, both the SLR and 126 designs had their origins in the viewfinder design they were to supplant. In terms of technical specification, the SLR is arguably the most flexible configuration thus far developed. The design can cater for an extremely wide range of interchangeable lenses (from wide angle to telephoto) enabling the user to take any subject matter, interchangeable viewing/focusing screens incorporating (reflexive) light metering, a focal plane shutter that facilitates a wide range of exposure settings, and there are connections for hand-held and studio flash. The design uses the 35mm film format. The shape of the SLR camera is distinct to its forebear. Rather than a separate viewfinder, the SLR has a centrally placed dome that houses a pentaprism. This pentaprism allows the user to view the image formed by the lens when looking through an eyepiece at the back of the camera. The ability to view the actual image formed by the lens is important, both for improving the accuracy of composition and for eradicating the problem of parallax error, enabling all possible subject matter to be photographed.

The first SLR camera using 35mm film was the Exacta Varex, manufactured by Ihagee in East Germany in the early 1950s. This was an updated version of a pre-war camera, the Kine-Exacta, the most notable change being the addition of a pentaprism. In the mid-1950s SLR models were launched by Alpa in Switzerland, and Edixa and Contarex in West Germany. SLR models quickly grew in popularity in Japan around the same time. However, post-war import restrictions in many western European countries meant Japanese models did not begin to appear until after their removal in mid-to the late-1950s. It was the SLR which provided Japanese manufacturers such as Asahi-Pentax, Canon, Nikon and Minolta with an opportunity to break into U.S. and western European camera markets. They entered these markets with well-built, competitively priced cameras that contained many innovative features.

The rise of the Asahi Optical Company is a case in point. Production of binoculars and viewfinder cameras began in 1947 with a staff of 20. Initial success lay in the binocular side of the business. In the early 1950s the company took advantage of the domestic boom in consumer spending associated with Japanese post-war recovery, and sales of cameras began in earnest. The company launched the Asahiflex, the first Japanese SLR. By this time the plant was employing 255 staff. In 1954 Asahi invented the instant return mirror and in 1957 the Pentax (named after its seven sided prism) was launched. In 1962 a European operation began in Belgium and two years later the Spotmatic model was launched with the world's first through-the-lens metering system powered by a cadmium sulphide (CdS) cell[2]. In 1966, Asahi produced its millionth SLR camera. In 1962 it passed the two million mark, and in 1971 it passed the three million mark. The Asahi story is impressive, but it was not the only one. Comparable examples of product innovation, founded on impressive advances in optical, mechanical and electrical engineering were found amongst other Japanese producers, who developed electronically controlled shutters and zoom lenses. Later, through the application of semiconductor technology to the SLR design, Japanese manufacturers introduced autofocusing, patterned metering, and programmed autoexposure. By the mid-1970s, Japanese manufacturers dominated the 35mm photography market. They were to subsequently use this success as the springboard to enter other niches within the camera industry. Pentax and Minolta entered the professional markets in the late 1970s with the release of their own medium format camera designs, while Canon and Minolta quickly moved into the compact camera market when this new niche opened up.

The first compact camera, the Kodak Instamatic 100, was introduced in 1963. Launched as the 'peoples camera', it was the first design explicitly developed and properly marketed to the mass market since the Kodak Box Brownie in 1900 (Economics Intelligence Unit, 1979). In many respects the design was a clever simplification of the viewfinder design. Notably, the Instamatic had a built-in lens with a fixed focal length of around 3m giving tolerably sharp results from 1.5m to infinity. For the first time, widespread use of plastic was made throughout its construction. Taking advantage of advances in plastic extrusion technology, Kodak developed a design that could be produced very cheaply and in large quantities. In addition to the body being made of plastic, the lens was made of plastic. Shutter speeds in the original model were limited to 1/90 second for bright conditions and 1/40 second for overcast conditions, so flash was need in dim lighting conditions to illuminate subjects up to 4m from the camera. A second important simplification of the viewfinder design involved the substitution of the focal plane shutter with a small plastic blade placed directly behind the lens. The blade shutter design was first introduced by Kodak in the Retina Reflex, a viewfinder camera, in1956 (Coe, 1988). Its use within a viewfinder severely limited the range of interchangeable lenses that could be used. Notably, wide-angle lenses have short focal lengths which need to be positioned close to the film surface. Unfortunately, inserting a wide-angle lens into the Retina body would result in the back of the glass either pushing against the blade shutter, rendering the camera inoperable. However, in the context of a fixed lens design, the blade shutter offers a simpler and far cheaper alternative to the focal plane shutter.

A complementary and equally radical innovation, introduced alongside the Instamatic 100, was the 126 film cartridge. This was the first successful breakaway from the

[2] Prior to CdS cells, cameras had used photoelectric cells. In addition to their being less energy efficient, photoelectric cells needed to be located externally on the camera body, giving an incident light reading of the amount of light falling on the camera. By contrast, CdS cells facilitated the development of reflexive light meters that calculate the light reflected back though the pentaprism from the scene itself.

traditional roll film and 35mm film cassette. The camera was designed to operate with this specially designed cartridge, which housed a 35mm film with a black backing paper on which exposure numbers were printed. These, together with information on the film type located on the back of the cartridge, could be seen through a rectangular slot on the camera back. The 126 cartridge was designed to eliminate one of the consumer problem areas – that of loading the film. This, the marketers suggested, is the most common source of damaged films. The cartridge dropped into the body, the user did not need to load film on to a spool, or rewind the film after use[3].

The shake-out that occurred in the camera industry had two aspects. First, there was a new cycle of market entry and exit amongst the competing producers of SLR designs and 126 designs. Second, the switch on the part of consumers from viewfinder to SLR and 126 designs saw the disappearance of many German manufacturers who had previously been the dominant market players. Using data provided by annual camera guides issued by 'Amateur Photographer', the leading amateur magazine in the UK, one can examine changes in market entry and entry amongst SLR and 126 producers between 1955 and 1974 (Figures 1 and 2). Figure 1 indicates an unexpected finding. Looking at the total numbers of SLR camera producers, this first rises and then remains at a reasonably constant level. By contrast, the numbers of producers of 126 designs initially rises and then later declines following a shake-out.

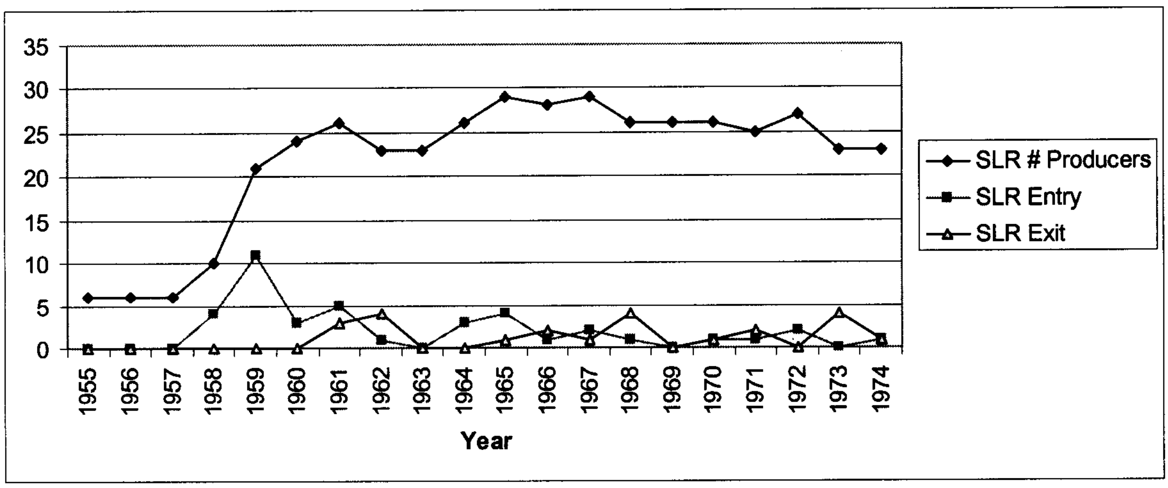

Figure 1. Levels of entry and exist amongst SLR producers, 1955 – 1974

[3] The basic design of the compact camera purchased today is almost identical in specification to the original Kodak Instamatic. The one noticeable difference is the use of the traditional 35mm film cassettes as the 126 cartridge fell out of favour in the late 1970s.

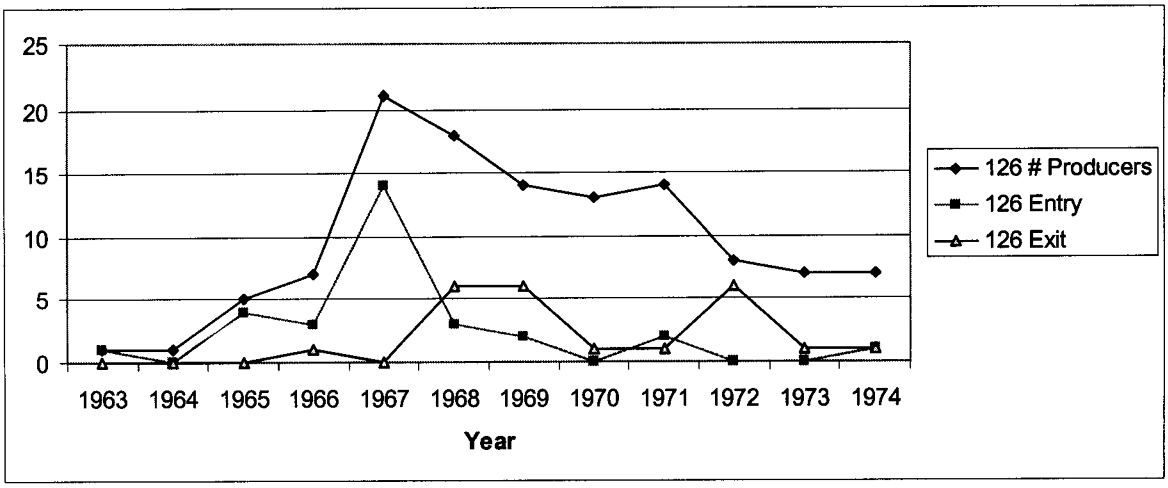

Figure 2. Market shake-out of 126 producers, 1963 - 1974

As noted, we are not only interested in changing numbers of producers in the SLR and 126 markets but also their national origin. For this reason, each producer is classified according to four categories: U.S., European, Japanese, and other. Figure 3 indicates that the number of Japanese makers in the SLR niche grew more rapidly than the number of European makers, exceeding the number of European makers for the first time in the early 1960s. The number of European makers peaked in 1957 but declined rapidly thereafter. The data indicates that the number of Japanese and European producers grew rapidly in the 126 market prior to a shake-out between 1967 and 1973. This shake-out saw a fall in both the number of Japanese and European makers.

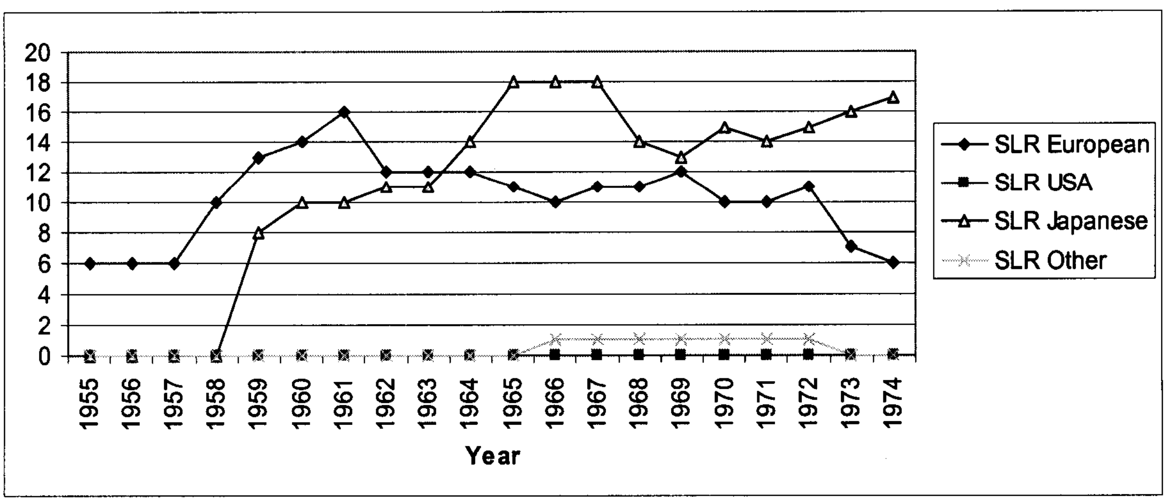

Figure 3. Number of SLR producers by national origin, 1955 - 1974

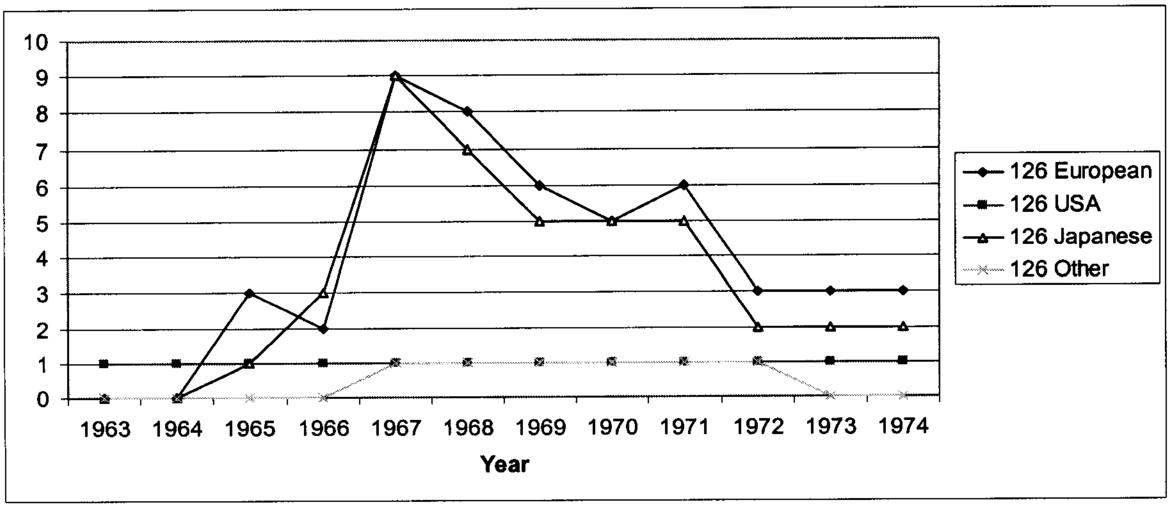

Figure 4. Number of 126 producers by national origin, 1963 - 1974

The data for 126 producers is consistent with empirical observations of industry shake-outs, with one important proviso: these occurred in a mature industry. The number of producers grows initially and then reaches a peak, after which the number declined steadily, despite continued growth in industry output. A key factor was the rate of market entry, which initially rose sharply in both the 126 niche but fell, equally sharply, thereafter.

The rapid expansion of Japanese companies in these new market niches is indicated by the growth in the number and value of Japanese exports of still cameras between 1955 and 1965 (Table 1). By 1976, Japanese exports of still cameras exceeded 6.2 million units per year (Economics Intelligence Unit, 1979).

Year	Number of units exported (000's)	Value
1955	235	$0.014m
1956	387	$0.025m
1957	559	$0.538m
1958	*	*
1959	*	*
1960	*	*
1961	849	$20.0m
1962	1,103	$29.4m
1963	1,252	$36.3m
1964	1,412	$42.7m
1965	1,611	$52.4m

Source: Perspective (1959, 1966).

Table 1. Exports of Japanese still cameras, 1955-1965.

Ideally, one would like to examine the industry shake-out amongst German viewfinder manufacturers, as consumers switched to SLR and 126 cameras, by examining changing market shares in global markets. Unfortunately, market share data is notoriously difficult to obtain sales figures from companies in order to gain a picture of buyer trends, and the camera industry is no exception. Having said this, two consumer surveys, both conducted in 1979 in the U.S. and the UK, clearly indicate the extent to which consumers had switched to SLR and 126 cameras by the end of the 1970s.

Type	Market share (by value)
35mm viewfinders	8.6%
35mm SLRs	19%
126/Instant cameras	67%
Roll film	3.4%
Other	2%

Source: Economics Intelligence Unit (1979).

Table 2. Market share of new cameras in UK by type of system, 1979.

The 1979 PMA Consumer Photographic Study, conducted by The Photo Marketing Association in the U.S., reported the results of 1638 completed questionnaires sent out in 1978. 49% owned a 126 format camera and 29% stated they owned a 35mm SLR camera (Shriver, 1979).

To summarise, the camera industry has important phenomenological and theoretical implications for our understanding of innovation life cycles. Not only was the success of the SLR and 126 designs associated with the bifurcation of the amateur market into two distinct market niches, it was also associated with a *new* innovation life cycle in a *mature* industry. Further, these radical designs were championed by new market entrants, most notably by new Japanese start-ups. Through radical product innovation these new entrants overcame the first mover advantages enjoyed by German manufacturers. Indeed, Japanese companies succeeded in becoming the new dominant market players in the industry. Many German manufacturers disappeared as amateur users replaced their viewfinder cameras with SLRs and 126 designs. Section 1 of the paper discussed the conundrum that is posed by the introduction of automated exposure mechanisms, an incremental modular innovation. It is to this conundrum that we next turn.

3. Incremental innovation: the introduction of automated exposure systems

Conventional life cycle theory predicts that incremental innovations that improve the performance of a design will initially be introduced in higher priced models (in order to recoup R&D costs). If successful, an incremental innovation will subsequently be offered in lower priced models. Automated exposure mechanisms (AE) were introduced in SLR designs in 1961 and in 126 designs in 1963. Yet, while AE was quickly adopted in the lower priced 126 designs, it proved was not a popular in the higher priced SLR cameras, turning conventional innovation strategy on its head. This section starts to address the conundrum by applying the Henderson-Clark typology of incremental innovation to AE mechanisms. This provides a basis for the empirical investigation, conducted in sections 4 and 5, of the shadow prices charged for AE in SLR and 126 cameras. Shadow prices are an indicator of users' evaluations of different product features. If the shadow prices for AE are found to differ significantly between SLR and 126 cameras, then this indicates the purchases of these cameras have very different subject valuations. Section 6 considers why these valuations may differ, and the theoretical implications that this has for conventional explanations of innovation life cycles.

Henderson and Clark (1990) identify two sources of incremental improvement in design performance. The first involves an improvement in the quality of an existing component of a design configuration, the second involves a modular innovation. An example of the former is the performance improvement wrought by successive generations of the Intel 808X family of semiconductors. Modular innovation, by contrast, involves either the substitution of existing modular components or the addition of new modules that extend the functionality of a design configuration. Examples of modular substitution include the replacement of mechanical movements by quartz in watches, and the replacement of analogue telephone exchanges with digital telephone exchanges. Examples of improved functionality through the introduction of new features include CD Rom drives in personal computers, and the improvement of car passenger safety through the introduction of airbags. The introduction of AE also fits into this category. The addition this new module was intended to improve the performance of both the SLR and 126 camera designs.

The accurate exposure of a film requires the balancing of lens aperture and shutter speed such that the correct amount of light reaches a light-sensitive film emulsion. Different combinations of aperture and shutter speed are possible. For example, each of the combinations of shutter speeds (in seconds) and lens aperture (*f*-stop) listed in Table 1 will produce the same amount of exposure. The relationship between lens aperture and light is direct. Taking a picture with the lens aperture set to *f*4 and then changing the aperture to *f*5.6 will halve the amount of light entering the camera. A further stop down to *f*8 will have the amount light of light again, and so on. Altering the speed with which the blades of the shutter mechanism open and close also determines how much light reaches the film emulsion. Taking a picture at 1/500 sec., for example, and then changing the shutter speed to 1/1000 sec. will halve the amount of light falling on the film emulsion. By contrast, changing the shutter speed to 1/250 sec. will double the amount of light. Thus, in order to achieve an equivalent exposure, moving down one aperture stop (a doubling of the amount of light entering the camera) requires a compensatory halving of the shutter speed.

The third factor affecting the density of the recorded image is the sensitivity to light of the film itself. For example, a film with a rating of ISO 400 is twice as sensitive to light as a film rated ISO 200, which is turn is twice as sensitive as an ISO 100 film. Hence to produce an image of a given density one needs to give an ISO 400 film half as much exposure as an ISO 200 film, and one-quarter the exposure of an ISO 100 film.

*f*22 1/15 sec	*f*16 1/30 sec	*f*11 1/60 sec	*f*8 1/125 sec	*f*5.6 1/250 sec	*f*4 1/500 sec	*f*2 1/1000 sec

Table 2. Alternative combinations of lens aperture (*f*-stop) and shutter speeds (sec.) producing an equivalent amount of exposure.

An AE mechanism selects an appropriate combination of (*f*-stop) and shutter speed to ensure that an image of appropriate density is captured on film. This is achieved by cross-coupling the lens diaphragm and shutter speed to a light meter. Three forms of automation were available on the market at the outset of the 1960s (Amateur Photographer, 1960). In order of technical sophistication, the simplest AE mechanism fixed the shutter speed according to the ISO of the film being used while the light meter established an appropriate *f*-stop. The second type of AE had a pre-set series of available combinations of *f*-stops and shutter speeds. Selection of a particular pre-set combination was made according to film ISO and the available light. The third type of AE available in 1960 was shutter-priority AE. Here the user selects the desired shutter speed and an appropriate *f*-stop for that shutter speed is automatically selected.

Shutter-priority AE first appeared in 1961 on an SLR camera (the same year Kodak launched the first 126 camera, the Instamatic 100). The first 126 design to offer AE, was the Kodak Instamatic 304, introduced in 1963. This used the simplest 'type I' AE mechanism. Given that this camera was only switching just two shutter speeds, a simple set-up was the most appropriate. The appearance of three Japanese models in 1966 - the Minolta Autopak 700, the Ricoh 126C Automatic, and the Yashica EZ Matic– marked an important point in the development of the 126 compact design. These were the first models offering a wide range of shutter speeds (1/30 to 1/250, 1/30 to 1/300, and 1/30 to 1/300 respectively) and, simultaneously, they incorporated a sophisticated shutter-priority AE device. The first aperture-priority AE camera was launched in 1969. Later, after the historical period under consideration, fully automated aperture-shutter programmed AE was introduced into the market, again by Japanese manufacturers, and again initially in the SLR market. It is to an examination of the reaction by amateurs to the introduction of shutter-priority and aperture-priority AE in SLR and compact camera designs that we next turn.

4. Empirical testing using hedonic price analysis

A systematic investigation into the existence of multiple market niches, containing user groups with distinct preference sets, can be made via Lancaster's characteristics approach (1971, 1991). Lancaster observed that "the good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristics give rise to utility" (Lancaster, 1991, p.13). Hence consumers are not interested in technology for itself but in the stream of services that the technology delivers. Furthermore, the evolution of a product can be modelled by examining the evolution of the key characteristics it offers consumers. If distinct sets of consumer groups are present in the market, then, ceteris paribus, products with quantitatively distinct sets of characteristics will develop as firms seek to gain competitive advantage through product differentiation (Windrum and Birchenhall, 1998).

With regards to incremental innovation in a design, the Henderson-Clark typology of incremental improvement through improved quality of an existing component and/or modular innovation can be captured in the following manner. Let the product p_i be described by a vector of x_i attributes, where $i = 1, \ldots, n$. Next, let us simplify by assuming that each attribute x is independently related to one modular component c of the design, such that $x_i = c_i$. Given independence between characteristics, improvement in the quality of a particular component will incrementally improve the performance of its associated characteristic, raising the overall performance of the product. Alternatively, overall performance can be raised through the addition of a new module and associated attribute. Whether an incremental innovation enhances the competitive advantage of the innovating firm depends on two factors. First, the cost of the innovation and the resultant change in the price charged for the product and, second, consumer preferences. Clearly, sales will not improve if the targeted consumers do not value the new/improved attribute. In terms of assessing AE, one can, in principle, assess the degree of acceptance of this modular innovation by different consumer types via an estimation of the hedonic prices charged for the attribute. As Saviotti observed, hedonic prices can "be considered an approximation of users' judgement of the relative value of the various characteristics offered by a product" (Saviotti, 1985, p.312).

In addition to the shadow prices paid for particular product characteristics, testing for brand equity – the willingness of consumers to pay higher prices for particular marques – is an indicator of the ability of new Japanese companies to establish good reputations for quality in the market, and also the ability of the previously dominant German producers to maintain theirs.

Marketing literature has given much importance to brand names over the last decade. Research into 'brand equity' was prompted by the work of Aaker (1991, 1996) and Keller (1993, 1998), with subsequent case study and cross-sectional panel analyses seeking to identify premiums paid for brand names (e.g. Park and Srinivasan, 1994; Ragaswami et al., 1993). As far as the author is aware, brand equity has not previously been examined within the context of hedonic price analysis. Following the

Hendry 'general-to-specific' approach to econometric estimation, we shall consider whether brand names also have identifiable hedonic prices as these would indicate that a premium was being paid for this brand name. A number of leading German, US and Japanese brand names have been discussed in connection with the development of SLR and126 designs, and with the early development of AE: Agfa, Asahi-Pentax, Canon, Kodak, Minolta and Nikon, Rollei, and Zeiss. It therefore seems pertinent to include these brand names within the analysis.

The theoretical and empirical discussion raises three propositions that will be tested:

Proposition 1: Two distinct sub-niches exist within the amateur camera market.

Proposition 2: The valuations of AE by alternative groups of amateur users differ.

Proposition 3: Brand equity is an explanatory variable of price.

Proposition 1 can be tested by first estimating a statistical model that includes both SLR and 126 cameras. The estimated structure of this 'combined' model can then, using the Chow test for parameter stability, be compared with the estimated structures of separate statistical models for SLR and 126 cameras. If there is no statistical difference between the combined and the separate estimated models, such that $Model_{SLR+126} = Model_{SLR} + Model_{126}$, then we accept the null hypothesis that the amateur camera market does not contain two distinct sub-niches. If, however, the Chow test supports the alternative hypothesis that two distinct sub-niches exist, i.e. $Model_{SLR+126} \quad Model_{SLR} + Model_{126}$, then we can proceed to *Proposition 2*.

Proposition 2 suggests that users of SLR and 126 cameras not only have distinct preferences but that they placed different valuation on *AE* in the estimated period (1965-1974). This is readily examined through an inspection of the estimated coefficients of *AE* for each of the separate estimated models. Likewise, *Proposition 3* can be examined through an inspection of the brand names that appear to be statistically significant in the estimated SLR and 126 models for the period 1965-1974.

In accordance with the general-to-specific estimation approach, the most general possible model, including all SLR and 126 attributes together with the brand names identified, is estimated. Thereafter a stepwise elimination of non-explanatory variables is conducted until the simplest model containing only explanatory variables is derived. This combined model will be compared with separate estimated models for SLR cameras and 126 cameras derived in the same manner. The resulting models are reported in section 4.

The data set is drawn from issues of the UK 'Amateur Photographer'. This weekly publication has consistently been the best selling amateur photography magazine in the UK dates since its first edition in 1884. During the period under consideration, the magazine published an annual guide to still cameras. This listed all the products available on the UK market and included both prices and technical product specifications. This single source thus provides a data set that is both consistent and complete for the period 1965 to 1974.

The data set contains information on five product characteristics: the range of range of shutter speeds offered, whether the shutter is mechanically or electronically controlled, the speed of the standard lens sold with the camera, the option for using interchangeable lenses, and whether a metering system is built-in to the camera. Information on the range of shutter speeds offered in the design has been converted into a scale in order to capture the flexibility offered to the user. As noted previously, each doubling (halving) of shutter speed is equivalent to one stop. For example, a range of shutter speeds from 1/30 sec. to 1/500 sec. represents 4 stops. Data on the number of stops offered by each camera model is listed in the variable *SS*. The variable *LS* indicates the speed of the standard lens that is sold with the camera. In order to obtain comparability between the different lenses, the original data again needs to be converted into a scale. Here a log scale is used with a maximum value of 8 accorded to the fastest (theoretically) conceivable lens[4] having an open aperture of *f*1 while the lowest value of 1 is accorded to an open aperture of *f*22.

The remaining three product characteristics contained in the data set are treated as dummy variables. *IL* is a dummy variable indicating whether or not the camera provides an option for the use of interchangeable lenses, *M* is a dummy indicating whether or not metering system is built-in to the camera, and *M/E* is a dummy indicating whether the shutter mechanism is mechanically or electronically controlled. In addition to product characteristics, a series of dummy variables are used to test for equity associated with brand names. The brand names that are listed as dummy variables in the data set are as follows

AB = Agfa Brand	*NB* = Nikon Brand
CB = Canon Brand	*PB* = Pentax Brand
MB = Minolta Brand	*LB* = Leica Brand

5. Results

5.1 Model 1: Combined model of SLR and 126 cameras

Using the general-to-specific method of variable selection for Model 1, the non-explanatory variables are eliminated in the following order: *AE*, *KB*, *ZB*, and *RB*. The best model includes *IL*, *SS*, *M*, *LS*, *M/E*, *AB*, *CB*, *LB*, *MB*, *NB* and *PB*, the estimated model being

[4] An *f*1 lens is an ideal lens with no measurable optical distortion. The most accurate lens commercially available during the period 1965-1974 had an open aperture of *f*1.2.

$$P_{LOG(SLR+126)} = \underset{(8.543)}{.326} + \underset{(10.960)}{.285\,IL} + \underset{(11.023)}{.251\,SS} + \underset{(9.060)}{.127\,M} + \underset{(14.399)}{.331\,LS} + \underset{(6.939)}{.095\,M/E}$$

$$+ \underset{(2.079)}{.027\,AB^*} + \underset{(6.688)}{085\,LB} + \underset{(7.024)}{.091\,NB} + \underset{(5.140)}{.067\,CB} + \underset{(2.061)}{.026\,PB^*}$$

$$+ \underset{(4.885)}{.066\,MB}$$

R^2 *(adj.)* = .840 $\Sigma e^2 = 47.383$ $F = 484.895$ $dw = 1.561$
$n = 1080$

* statistically significant at the 0.05 level

where	P_{LOG}	= Log of price	*IL*	= Interchangeable lenses
	SS	= Range of shutter speeds	*M*	= In-built metering ystem
	LS	= Speed of standard lens	*M/E*	= Mechanical/ electronic shutter
	AB	= Agfa Brand	*NB*	= Nikon Brand
	CB	= Canon Brand	*PB*	= Pentax Brand
	MB	= Minolta Brand	*LB*	= Leica Brand

All the estimated coefficients have the expected (positive) signs. Notably, automatic exposure (*AE*) is the first variable to be removed via step-wise elimination of non-explanatory variables at the 0.05 level, followed by the brands Kodak (*KB*), Zeiss (*ZB*) and Rollei (*RB*). The estimated coefficients for all of the other product characteristics *IL, SS, M, LS,* and *M/E* are statistically significant at the 0.01 level. The estimated coefficients for the brands *LB, NB, CB,* and *MB* are statistically significant at the 0.01 level, while the estimated coefficients of *AB* and *PB* are statistically significant at the 0.05 level (*p* values are 0.038 and 0.040 respectively).

5.2 Chow test for parameter stability

Setting up the null hypothesis (H_0) that the sample does not contain two distinct sub-samples, we apply the Chow test for parameter stability by estimating separate statistical models for SLR and 126 cameras, and taking the residual sum of squares for each of the estimated three models. The test statistic has an F distribution with (k, n1 + n2 – 2k) d.f.

We test this using the most general estimated model for each of the three models (see appendix A1). The estimated F statistic = 37.438 with a critical $F_{0.01:\,15,\,1050} = 2.18$. Therefore we reject H_0 at the 0.01 level, and accept H_1 that the data sample contains two sub-samples (SLR and 126 designs) with distinct sets of product characteristics.

5.3 Model 2: SLR cameras

Since interchangeable lenses (*IL*) is a dummy variable and all SLRs in the data set have this option, the variable is omitted from the estimated regression. Further, Agfa and Kodak did not produce SLR designs during the estimated period and so the variables *AB* and *KB* are omitted from the analysis.

Using the general-to-specific method of variable selection for Model 2, the non-explanatory variables are eliminated in the order *AE* and *RB*. The best model includes *SS, M, LS, M/E, AB, CB, LB, MB, NB* and *PB*, the estimated model being

$$
\begin{aligned}
P_{LOG(SLR)} = \; & \underset{(8.468)}{.932} + \underset{(21.161)}{.494\,SS} + \underset{(9.133)}{.220\,M} + \underset{(2.597)}{.063\,LS} + \underset{(5.014)}{.124\,M/E} \\
& + \underset{(8.063)}{.178\,LB} + \underset{(10.857)}{.242\,ZB} + \underset{(9.247)}{.210\,NB} + \underset{(6.684)}{.155\,CB} + \underset{(2.512)}{.056\,PB^*} \\
& + \underset{(3.967)}{.096\,MB}
\end{aligned}
$$

$R^2\,(adj.) = .643$ $\Sigma e^2 = 21.748$ $F = 136.42$ $dw = 1.350$
$n = 816$

* statistically significant at the 0.05 level

Automatic exposure (*AE*) is the first variable to be removed via step-wise elimination of non-explanatory variables at the 0.05 level (p value = 0.567). It is interesting to note, in passing, that the estimated parameter for AE was negative (-.008). The estimated coefficients for all the other product characteristics (*IL, SS, M, LS* and *M/E*) are statistically significant at the 0.01 level and all have the expected (positive) signs.

The estimated coefficients for the brands *LB, ZB, NB, CB* and *MB* are statistically significant at the 0.01 level, while the estimated coefficient for *PB* is statistically significant at the 0.05 level (p value = 0.012). One brand, Rollei (*RB*) is not statistically significant at the 0.05 level and was consequently removed from the model.

5.4 Model 3: 126 cameras

The dummy variable for interchangeable lenses (*IL*) is omitted from the estimated regression because none of the 126 designs in the data set have this option. Further, the brands Asahi-Pentax (*PB*) and Nikon (*N*) are omitted because these manufacturers did not produce 126 designs during the estimated period.

The best estimated model for Model 3 includes *SS, M, LS, M/E, AE, AB*, and *MB*. Non-explanatory variables were eliminated in the following order: *CB* and *KB*. The final estimated model is

$$P_{LOG(126)} = \underset{(9.025)}{.352} + \underset{(3.439)}{.156\,SS} + \underset{(5.231)}{.226\,M} + \underset{(13.521)}{.487\,LS} + \underset{(2.428)}{.108\,M/E^{*}}$$

$$+ \underset{(5.174)}{.205\,AE} + \underset{(1.996)}{.066\,AB^{*}}$$

R^2 *(adj.)* = .730 $\Sigma e^2 = 9.238$ $F = 119.732$ $dw = 1.827$
$n = 264$

* statistically significant at the 0.05 level

All of the estimated coefficients have the expected (positive) signs. The most notable finding in this model is the estimated coefficient for *AE*, which is positive and statistically significant at the 0.01 level. The estimated coefficients for the dummy variable *M/E* is statistically significant at the 0.05 level (p value = 0.016) while the remaining product characteristics (*SS, M*, and *LS*) are statistically significant at the 0.01 level.

Contrary perhaps to our initial expectations, the estimated model suggests that Kodak was not earning brand equity. Indeed, when one looks at the data in more detail (see appendix A2), it transpires that the average price charged by Kodak for its 126 cameras over the period 1965 – 1974 was, on average, 25% lower than the average market price. The estimated model suggests that Agfa (*AB*), an equally well-known brand that had played an important role in introducing AE in viewfinder cameras, was able to earn brand equity in this period.

Examining the estimated models (2) and (3) in detail adds further supports *Proposition 1* that alternative groups of amateur users are readily identified in the data and, moreover, that the valuations of each group differed significantly in this period. Turning to *Proposition 2*, the estimated coefficient for *AE* in the SLR model was not statistically significant, indicating that 'serious hobbyists' did not positively value this attribute and, hence, were unwilling to pay a positive price for it. This contrasts strongly with statistically significant coefficient for *AE* estimated in the 126 model. These findings turn an important prediction of conventional life cycle theories on its head. AE was indeed introduced in first SLR cameras, the average price of which was more than 6 times that of 126 cameras (see appendix A3). Yet the historical record, supported by these findings, clearly indicates that this feature gained popularity amongst users paying for lower priced 126 cameras *despite* the fact that it did not become a popular feature in more expensive SLR cameras. In addition to strongly differing estimates of the hedonic price evaluations of *AE*, the coefficient estimates of the characteristics *SS* and *LS* in Models (2) and (3) are differ notably.

The estimated models offer some interesting insights into *Proposition 3*. Branding is one of the explanatory variables of price in each of estimated models. Interestingly, the significantly significant brand names differ between the user groups purchasing SLR and 126 cameras. In the SLR market, two of the old established German marques of Leica and Zeiss, famous for the high quality of their lenses, continue to attract a premium. The extent to which the leading Japanese companies had caught up with these marques is indicated by the fact that four of the 'big five' Japanese marques - Nikon, Canon, Pentax, and Minolta - are able to charge a premium in the SLR market. In the 126 market, the Agfa and Minolta marques are estimated to be statistically significant. Once again, the different structure of the estimated SLR and 126 models this supports the hypothesis that the preferences of consumers in the two niches of the amateur market are significantly different.

6. Explaining the findings

How may we explain these findings? The bifurcation of the amateur market into two distinct niches, following the launch of the 126 and SLR designs, suggests that an important starting place is the heterogeneity of consumer preferences within this market. The success of SLR and 126 cameras lay in their catering for the preferences and interests of two very different groups of users. Today, this is a widely commented upon feature of the industry (e.g. Economics Intelligence Unit, 1979; Retail Business, 1985).

The 'snapshooter' does not consider him/herself as a 'photographer', or in any sense an expert. They typically take pictures on holidays and special occasions such as birthdays and weddings. The average frequency of film purchase is two to four rolls per year, and film may be left in the camera from season to season. The snapshooter wants a low priced camera that is simple to operate, does not require much effort to learn how to use it. Another important consideration is the ready availability of colour film for their cameras, and the ability to readily have this processed and printed by the leading high street and mail order outlets. (S)he is not interested in photography as a creative pastime.

In sharp contrast to the snapshooter, the 'hobbyist', photography as a creative past time and is a form of artistic self-expression. To varying degrees, (s)he has grasped the technicalities of composition and of the different creative opportunities afforded by different shutter speeds, lens focal lengths, and flash photography, and will take pictures for most of the year. A photography magazine will be bought at least occasionally. The hobbyist is willing to invest in a highly flexible and sophisticated tool that enables him/her to take all manner of subject matters, and, moreover, is willing to pay a relatively high price for a camera of this quality. Slide film and black and while film may be as important as colour film. The hobbyist may also have his/her own darkroom or have access to a darkroom in which to do their own processing and printing.

Given the very different interests and preferences of these two user groups, one can readily appreciate the success of the SLR and 126 designs. The SLR design, with its interchangeable lenses of different focal lengths, offers the hobbyist a highly flexible and sophisticated tool that enables him/her to take all manner of subject matters. The hobbyist is willing to pay a relatively high price for a sophisticated instrument of this quality. By contrast, the 126 design met the very different interests and preferences of the snapshooter. Its design was very simple to operate, produced pictures of reasonable quality, and (because it is very cheap to produce) was highly affordable.

The camera industry example suggests that heterogeneity amongst users is an important explanatory factor for the emergence of distinct market niches. Yet conventional theoretical models of the life cycle assume that user preferences are homogeneous. In models where there are homogeneous consumer preferences, firms will experiment with alterative designs until a dominant/standard design is identified which satisfies a fixed, unique preference set for a given cost/price constraint. In the presence of heterogeneous preferences one would not expect a single design to be predominant over time.

Windrum and Birchenhall (1996) have gone further, arguing that innovation is driven by the interaction between consumers preferences and the technological learning of firms. Further, preferences themselves evolve as consumers individually and collectively explore the potential benefits of different technologies. These feed back to firms who seek competitive advantage through product innovation. Through product and process innovation, firms aim to improve the service characteristics of the products offered to their target consumer groups. As firms and consumers learn through their experiments, so products characteristics change.

This concept of co-evolutionary interaction between consumer and firm learning would seem to explain two important aspects of the camera industry. First, as highlighted in the original Windrum and Birchenhall paper, the industry saw the development of alternative design configurations with distinct characteristics - optimised for the particular needs of different users groups - that are sold in different market niches. Second, these different user groups are likely to respond in different ways to the introduction of subsequent modular innovations. The data presented in section 5 indicates that this was the case for early automatic exposure devices when they were introduced in the SLR and 126 designs.

Snapshooters quickly adopted automated exposure in the 126 design and, as indicated by the estimated coefficient for AE in Model 3, were willing to pay a price for this feature. By contrast, the estimated coefficient for AE in Model 2 indicates that SLR users were noit willing to pay a price for this additional feature. The differences in attitude towards AE are summed in two pieces of text that taken contemporary articles published in the Amateur Photographer magazine.

> "[U]ndoubtedly any camera that provides almost foolproof results on average subjects from the word 'go' will appeal very strongly indeed to the new-comer to photography and to all those for whom figuring out shutter speed and f/stop variations is a difficult process... The advanced worker is more likely to be interested in things that *directly* improve performance" (Smith, 1960, p.4, italics in original).

Here a keen distinction is drawn between, on the one hand, those starting out in photography and for snapshooters, for whom calculation of exposure presents a difficult task and, on the other, the 'advanced worker' (hobbyist). The second article clearly voices the concerns of the hobbyist towards AE,

> "The automation of camera controls has certainly not solved all the amateur's problems. Automatic coupling is good when it reduces the number of controls to set, but it is not so good when it instils a belief in the camera owner that he only has to 'press the button' to get a good picture. And although the coupling of aperture and shutter speed will always provide the correct ratio, the user must still decide which combination suits his subject best. He must know or find out... what effect altering the aperture has, and what shutter-speed will stop subjects moving at various speeds. So even the not-so-serious amateurs have discovered that they must still acquire the fundamentals of picture-taking and that automatic controls give them no more than a well-exposed negative" (Freytag, 1959, p.599).

So, while snapshooters with 126 cameras were keen to adopt AE, and other incremental innovations that turned picture taking into a point-and-shoot exercise, the initial reception by hobbyists was very different because they wanted to keep as much control as possible over the picture taking process. Indeed the texts suggest that hobbyists almost viewed AE as a threat because it took away the ability to chose between different aperture-shutter combinations. As the second author makes clear, choice amongst the different combinations opens the way for creativity on the part of the photographer. Altering shutter speed affects the way in which action is captured, and aperture selection is important to the rendering of the field of focus in the final image. Thus, the selection of a particular aperture-shutter combination is an important creative decision for the hobbyist. This helps explain why hobbyists shunned the early AE mechanisms. During this period 1965-1974, 22 of the 30 most expensive SLRs – 'serious' cameras such as the Nikon F1 and F2, the Leicaflex SL, and the Canon FT – were all-manual designs that did not offer AE[5]. It was not until the application of semiconductor technology to the SLR design in the early 1980s, facilitating the development of far more sophisticated programmed autoexposure systems (and also autofocusing and patterned metering), that hobbyists adopted automated exposure.

7. Conclusions

The camera industry raises important questions regarding the conventional phenomenological account of the innovation life cycle (Klepper's stylised facts), and, in turn, the theoretical models that seek to explain this account. According to the conventional account, a process of market shake-out occurs in the early stage of the life cycle with no major product innovation occurring thereafter. Scale and learning economies, and other first mover advantages are thought to place dominant firms in an unassailable position. Consequently, we would expect a mature industry to be characterised by a small number of producers, the likelihood of new market entrants to be extremely low, and innovation to be incremental in nature. Yet in this mature industry a new set of market entrants – primarily Japanese – were able to overcome the first-mover advantages of US and European firms and, what is more, displace them as the dominant market players within just 15 years. The previously dominant German companies such as Leica, Contax, Voigtlander and Zeiss, who had been highly successful in producing the old dominant/standard viewfinder design, went into decline. Further, the success of the new Japanese entrants was achieved through the introduction and development of new product designs, initiating a new cycle of radical product and process innovation in this mature industry.

The history of the camera industry draws attention to two factors that require attention in future theoretical work. The first is the existence of heterogeneous consumer preferences. The amateur camera market is characterised by two distinct user groups. In the 1940s and early 1950s, both groups had bought slightly differentiated price-quality versions of the viewfinder camera, conforming to the conventional life cycle account. However, this was an unstable equilibrium, exposed by the subsequent introduction of designs that were better suited the needs and preferences of these distinct user groups. At this point, the market bifurcated into distinct product niches, a feature that remains to this day. The second factor that requires attention in future theoretical work is the interaction between consumer preferences (which themselves evolve over time) and firm learning.

[5] It was not until the application of semiconductor technology to the SLR design in the early 1980s, facilitating the development of far more sophisticated programmed autoexposure systems (and also autofocusing and patterned metering), that hobbyists adopted automated exposure.

As well as being important in explaining the bifurcation of the camera market, these factors help explain the adoption patterns of AE, an incremental innovation, in 126 and SLR. Conventional life cycle theories, such as the Abernathy-Utterback and Klepper models, predict that firms will initially offer new/improved features in higher priced versions of a dominant/standard design and that, if they prove popular then they will subsequently be introduced in lower priced models. AE was indeed introduced in first SLR cameras, the average price of which was more than 6 times that of 126 cameras. Yet the historical record, supported by the analysis conducted in section 5, indicates that AE was not a popular feature in SLR cameras while it quickly became a common feature in 126 cameras.

The paper has argued that this conundrum can be explained through an examination of the different interests and preferences of the two key user groups - snapshooters and hobbyists – who make up the amateur camera market. Whereas AE suited the snapshooters who purchased the cheaper 126 models, it did not (at least in its earliest form) suit the needs of hobbyists who purchased the more expensive SLR cameras. Hence, snapshooters were willing to pay a (shadow) price for this particular attribute while hobbyists were not. Further, the estimated models for SLR and compact cameras indicate that the preferences of these two users groups were also notably different with respect to other product attributes, and with respect to brand names within the two market niches.

To conclude, the findings of the paper suggest that future theoretical and empirical research on innovation life cycles should consider the heterogeneity of consumer preferences, and the ability of late market entrants to overcome the first mover advantages of dominant firms through radical product/process innovation. Japanese companies were not only successful in entering the camera market but also other mature industries such as motorbikes, automobiles and electrical goods in the 1960s and 1970s. A greater appreciation of the success of these companies will assist in strengthening our understanding of innovation life cycles.

APPENDIX

A1. Most general estimated models (initial regressions)

A1.1. Model 1: Combined SLR + 126 cameras

Independent Variables	Unstandardised Coefficients B	Std. Error	Standardised Coefficients Beta	t-ratio	p-value
(Constant)	.315	.042		7.535	.000
Interchangeable lenses	.354	.032	.286	10.924	.000
Range of shutter speeds	3.439E-02	.003	.250	10.950	.000
Metering system)	.144	.016	.126	8.977	.000
Lens speed	.121	.009	.334	14.089	.000
Mech/electronic shutter	.146	.021	.096	6.955	.000
Auto exposure	7.509E-03	.019	.005	.403	.687
Leica Brand	.372	.055	.085	6.708	.000
Rollei Brand	.103	.126	.010	.821	.412
Zeiss Brand	4.086E-02	.056	.009	.736	.462
Nikon Brand	.223	.032	.092	7.056	.000
Canon Brand	.140	.027	.068	5.161	.000
Pentax Brand	8.657E-02	.041	.027	2.109	.035
Minolta Brand	.146	.030	.066	4.867	.000
Agfa Brand	9.880E-02	.046	.029	2.131	.033
Kodak Brand	2.173E-02	.034	.009	.638	.524

Dependent Variable: Price Log

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.917	.842	.839	.2174	1.565

	Sum of Squares	df	Mean Square	F
Regression	251.564	15	16.771	354.978
Residual	47.292	1001	4.725E-02	
Total	298.857	1016		

A1.2. Model 2: SLR cameras

Note the following variables are constants and are omitted from the analysis: Interchangeable lenses, Agfa, Kodak.

Independent Variables	Unstandardised Coefficients B	Std. Error	Standardised Coefficients Beta	t-ratio	p-value
(Constant)	.939	.110		8.527	.000
Range of shutter speeds	6.286E-02	.003	.494	21.119	.000
Metering system	.143	.016	.219	9.060	.000
Lens speed	4.062E-02	.016	.061	2.531	.012
Mech/electronic shutter	.106	.031	.132	3.431	.001
Auto exposure	-7.359E-03	.032	-.008	-.231	.818
Leica Brand	.446	.055	.178	8.089	.000
Rollei Brand	.159	.099	.035	1.600	.110
Zeiss Brand	.335	.031	.243	10.888	.000
Nikon Brand	.233	.025	.210	9.275	.000
Canon Brand	.156	.023	.157	6.741	.000
Pentax Brand	8.289E-02	.032	.057	2.554	.011
Minolta Brand	.102	.031	.094	3.343	.001

Dependent Variable: Price Log

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.806	.649	.643	.1711	1.173

	Sum of Squares	df	Mean Square	F
Regression	40.061	12	3.338	113.998
Residual	21.671	740	2.928E-02	
Total	61.732	752		

A1.3. Model 3: 126 cameras

Note the following variables are constants and are omitted from the analysis: Interchangeable lenses, Nikon, Pentax.

Independent Variables	Unstandardised Coefficients		Standardised Coefficients	t-ratio	p-value
	B	Std. Error	Beta		
(Constant)	.347	.042		8.256	.000
Range of shutter speeds	2.150E-02	.006	.155	3.338	.001
Metering system	.168	.032	.227	5.195	.000
Lens speed	.115	.009	.486	12.893	.000
Mech/electronic shutter	.166	.062	.126	2.694	.008
Auto exposure	.155	.034	.191	4.538	.000
Canon	-5.397E-02	.081	-.024	-.670	.503
Minolta	.111	.075	.052	1.491	.137
Agfa	8.602E-02	.043	.069	2.022	.044
Kodak	2.146E-02	.030	.025	.717	.474

Dependent Variable: Price Log

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.860	.740	.731	.1894	1.866

	Sum of Squares	df	Mean Square	F
Regression	25.947	9	2.883	80.335
Residual	9.115	254	3.589E-02	
Total	35.062	263		

A2. Average price of Kodak 126 models compared with the average market price of 126 cameras, 1965-1974

Average price of 126 cameras

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
13.85	17.87	16.15	17.01	14.39	17.07	18.17	10.59	12.84	22.35

Average price of Kodak 126 cameras

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
14.48	13.61	13.58	16.80	9.51	10.34	10.87	9.57	9.75	8.53

% difference between average price of Kodak models and average market price

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
4.61	-23.85	-15.88	-1.19	-33.93	-39.43	-40.16	-9.61	-24.07	-61.83

Average % difference over the period 1965 – 1974

-24.53

A3. Average price of SLR models compared with average price of 126 models, 1965-1974

Average price of SLR cameras

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
95.77	88.90	70.92	99.97	108.18	97.69	116.45	129.96	142.76	168.31

Average price of 126 cameras

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
13.85	17.87	16.15	17.01	14.39	17.07	18.17	10.59	12.84	22.35

% difference between average price of SLR and 126 cameras

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
591.48	397.48	339.13	487.71	651.77	472.29	540.89	1127.20	1011.84	653.07

Average % difference over the period 1965 – 1974

627.29

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