

A Fortune No One Wanted

An investigation of the development of xerography

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The Birth of Xerox

The discovery and commercialization of xerography¹ is a unique story, with its own heroes and villains, but as a case study in innovation, the story of Xerox has been duplicated many times. Simply put, a man had an efficiency-enhancing idea for how to do a difficult thing with ease, namely, produce copies on plain paper. For twenty years, his idea was developed until it could be produced profitably. For a decade or so after that, Xerox had an effective monopoly on commercial copying with its xerography technology. Eventually, the Federal Trade Commission stepped in and used anti-trust regulations to force Xerox to license its technology to competitors. The introduction of competition generated new surplus as the technical innovation of Xerox was coupled with the user-loyalty enhancing innovations of the competitors who entered the market in the 1970s. Today, Xerox is still an active player in the market that it spawned, but the market is now competitive rather than monopolistic. Yet, had Xerox not earned those monopoly rents in the 1960s, the subsequent innovations carried out at the Xerox PARC² would never have happened, and the personal computer revolution may have been delayed for decades. There is an evolution here, witnessed across four decades in which the nature of the market changed from non-existent, to monopolistic, to competitive and at each juncture, there was an surplus-enhancing reason for the change. The insight suggests that new technology creates monopoly power for the innovator, but that as a market develops, those monopoly returns will eventually get stripped away until the competitive framework becomes dominant and the market finds zero-profit equilibrium.

¹ From the Greek for “dry writing.”

² Palo Alto Research Center, where the mouse, laser printing, and the graphical user interface were pioneered.

In 1939, the Haloid company, (which would become Haloid Xerox in 1958, and eventually just Xerox in 1961) was a small chemical company in Rochester, New York. They purchased the rights to the patents of a man named Chester Carlton who had been unable to interest a number of large firms in developing his idea for what he called “Electron Photography.”³ His patents describe in great detail the necessary steps involved in using electrostatic forces to print onto plain paper. Executives at Haloid saw the potential for the new technology if it could be made to work. The large corporations who Carlson initially tried to sell his patents to already had interests in other technologies that were technically inferior such as Therma-Fax and Verifax, which required special coated paper and “made curling, smog-colored copies that were hard to read, unpleasant to touch, and almost impossible to file” (Owen, 2004) Nevertheless, while imperfect they were already in production in the early 1950s while it was unclear if electron photography ever would be.

These companies also suffered from a complication inherent in any economic forecasting – the inability of a model to predict changes in the underlying demand for a service. The prevailing means of making copies were inefficient, required noxious chemicals, and didn’t last long. (Owen, 2004) Accordingly, no one involved in producing those machines imagined that anyone would want to do much copying at all, arduous as it was. The concept was so poorly understood at first, that salesman carried ragdolls to demonstrate that the machines could make flat pictures of 3D objects. The firms that rejected the opportunity to develop xerography failed to understand the potential this technology had to change the way people behave, and create a demand that did not previously exist.

³ US Pat. No. 2,221,776. (11.19.40)

Haloid had a distinct advantage insofar as they were pursuing a process which could theoretically produce lasting, high quality copies that lacked the flaws that plagued other copying technologies. The expense and tremendous risk involved in developing a commercially viable xerography technique would have thwarted a large company which has shareholders to answer to when pursuing risky projects. Thus, as von Hippel observes, those with the highest expected returns will be most likely to innovate, and in the case of Xerox, the small, hodge-podge Haloid company pulled a David and beat the big Goliaths. Their investment totaled \$12.5 million (in 1960 dollars) before the first commercially successful copier, the Xerox 914 went on sale in 1960 (Owen, 2004). The magnitude of their success and the rapid growth of Xerox is astounding, but what seems like a surefire win in hindsight often looks foolhardy along the way.

Xerography was a hard sell – Carlson, by his own estimation, took his idea to a dozen companies, each of which turned him down, before abandoning his search. He ended up selling his idea to a holding company in 1945 where the development rights were subsequently licensed to Haloid in 1946. Unsurprisingly, the large firms Carlson contacted were skeptical about taking this idea to market. Executives at Haloid, concerned with asserting a competitive position with the giant Eastman Kodak enterprise practically next door, embarked on a project that many supposed experts had refused to. Yet, over time, they grew to believe in their technology, and at times showed more faith that the original inventor in the potential of xerography. In 1953, Carlson expressed unhappiness with Haloid for not competing directly with Therma-Fax and Verifax, the two most successful copying options available at the time. In response, Joe Wilson, the CEO of Haloid wrote to Carlson:

“When you say we missed the boat completely, I, of course, believe the opposite. I believe that if we had taken the wrong boat two years ago we would be infinitely worse off now. Now we know what the real competition is. They have shot their wad.... Now we know what we have to do. Either we can beat those processes inherently, or we cannot.” (Owen, 2004)

But, as a small firm with all its eggs in one basket, the risks involved with making money off of xerography were justified because failure was not an option. Either it could be done, and they would make huge profits, or the idea would fail, and the stockholders (including employees who got stock in lieu of bonuses) would be out on their investment. Those at Haloid who understood the potential of xerography knew that if they could succeed, their process was undeniably better than the alternatives available in the 1950s.

Although the executives at Haloid knew they had a dynamite copying technology, they, like everyone else, had no idea what would happen when their machines went commercial. Even the engineers and scientists involved with building these machines did not appreciate how useful they were until they found themselves using the prototypes incessantly, with lines forming to use whichever machine was working that day (Owen, 2004). It was clear that if they could get the machine built, they would have a huge demand for it. But even their most optimistic expectations now seem laughably conservative. The story of Xerox demonstrates a key economic reality that many otherwise reasonable predictions often fail to account for – that a new product may, by coming into existence, create a demand that was not previously there. History is littered with such examples, but rarely has the innovation in question been greeted with such skepticism by those who would shortly come to find it indispensable. Schumpeter’s idea of “creative destruction” is applicable in the case of Xerox too. The Xerox 914 was

introduced into a market full of competing technologies – each with its own flaws and weaknesses – which today have all been supplanted by the advent of xerography.

Another innovative concept to emerge from the work-shop floor was the concept of metering copy use on a per page basis, coupled with a leasing model for the actual machines. This helped to compensate for the fact that the early copiers were heinously expensive to buy – a Xerox 914 cost \$2000 in 1960, compared with Kodak's cheapest coated paper copier at \$99.50 (Owen, 2004). Leasing the machines and metering them meant that Xerox learned early on that their estimates for the rate of use were far too low. The unexpected demand for copying put strain on both the machines and the fleet of repairman Xerox employed to fix them. It became economical for Xerox to lease additional copiers at reduced cost to large clients to reduce the chance of all the machines breaking simultaneously. This strategy paid for itself by reducing the number of repairmen required to service the fleet.

Another key to the success of Xerox was its use of patents. Chester Carlson, a patent attorney by profession, wrote meticulous patents designed to be as broadly applicable as possible. His skill in drafting patents, combined with the Haloid executives skill in defending their patents meant that Haloid had significant market power over the xerographic copying process. When IBM threatened to encroach on Xerox's turf in 1972, with a machine they had built at a huge expense of R&D workarounds, Xerox's attorneys brought hundreds of patents in their infringement suit. The dominant position of Xerox and its aggressive use of patents to hinder its competition eventually drew the attention of the Federal Trade Commission, resulting, in 1976, in compulsory licensing of Xerox patents. The intellectual protection embodied in Carlson's patents would lapse before

Haloid actually succeeded in bringing the 914 to market, but combined with the fiendish difficulty of actually building a machine capable of copying quickly and economically, the patents still helped Haloid gain an indomitable head start in commercializing xerography.

Like Mokyr and others have observed, the first innovation in a new direction is not necessarily going to be better than its contemporaries immediately. Rather, like steam engines and sailboats, the newer technology is gradually refined and developed until a sophisticated, user-friendly product emerges. Early xerography machines paled in comparison to comparable technologies of the time. But by the early 1960s, the xerography machine was ready for mass production. Within the first 3 months of 1960, 50 machines were produced, at a rate of approximately 5 per day. Soon, that number was increased to 25 per day with no increase in plant size. One hundred per day by the end of 1960, and ten thousand sold by late 1962 (Owen, 2004). Xerox took the problem child of xerography and raised it through its teething years, and deserves every cent of the profits that it earned.

The Golden Years

An investment of \$10,000 in Haloid stock in 1960 was worth \$1 million by 1972 (Owen, 2004) Xerography was a wholly new idea about how to make high quality copies, but the technical challenges were immense. Still, the difference between what Therma-Fax and Verifax machines were capable of and what a xerographical copier could do justified the extravagant cost of building the first machine. This investment was possible at Haloid in a way that wouldn't have been palatable to IBM's executives or their

shareholders. They persevered because they knew that ultimately, their technology was superior – it didn't curl, or fade or smell terrible like its competitors. Their success transformed the old Haloid chemical company, the 15th biggest company in Rochester, New York in 1959, into one of the 15 biggest companies in the U.S. by 1972 (Owen, 2004).

However, after reaping windfall monopoly rents and amassing huge amounts of liquid capital, the fruit of their faith in xerography, the market, aided by anti-trust litigation at the FTC that went against Xerox (FTC Annual Report, 1976), quickly caught up to Xerox and destroyed their monopoly control of xerographic techniques after more than a decade of unchallenged dominance. Monopoly control of xerography was first challenged by IBM which had invested in designing workarounds of Xerox patents and then overturned by the FTC. (see Fig. 1) Ironically, Xerox was the victim of its own success when the ease with which copies could now be made meant that legal discovery became “an open-ended orgy of photocopying.” (Owen, 2004) The introduction of competition indicates a new phase in the development of xerography from the technical innovations of simply getting the machine to work consistently to the user-experience enhancing innovations such as feeding-trays and automatic stapling. In this phase, no company had an inherent innovative advantage, because the core technology was made available for licensing. Furthermore, entrants to the market have more incentive to innovate than the sleeping giant they seek to supplant (Bresnahan, 1985). At the later end of the 1970s, as indicated in Figure 1, Xerox had caught up with its new competitors in the new race for user-friendliness, and a new competitive equilibrium was eventually established.

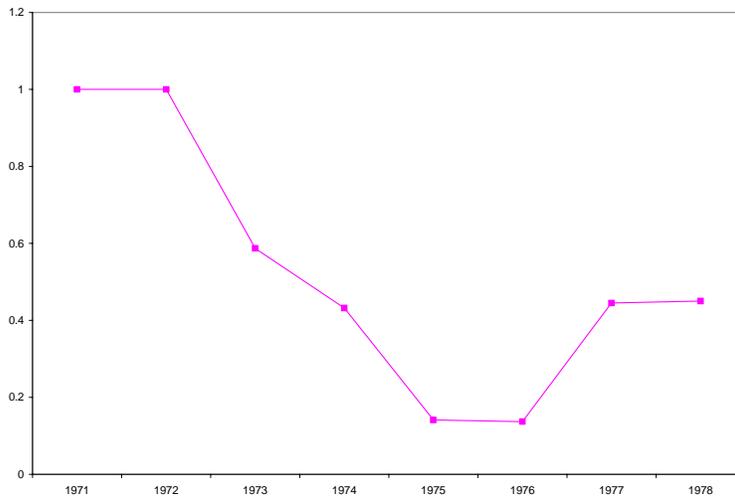


Figure 1. Xerox's Percent Share of New Orders

Xerox's success in achieving a commercially viable copy machine by the early 1960's was due in part to factors that it had no control over. Although patents held by Carlson and others at Haloid served as a deterrent for competition, so little was known then about the diverse individual technologies involved in electrostatic printing that it was theoretically possible that another firm may have developed a non-infringing technique, for example, laser printing, rendering the Carlson patents worthless. Von Hippel's functional theory of innovation posits that those with the highest expected return to innovation are most likely to innovate, and here, clearly, the scientists and engineers were highly motivated to conquer whatever hurdles were presented to them, especially when bonuses were paid in company stock, a decision that would produce dozens of millionaires out of Xerox by the 1970s (Owen, 2004).

Carlson had successfully demonstrated the theoretical potential of xerography back in 1938, but it took twenty years of sustained investment in R&D to create the 914 and help to jump-start the information age by creating the capacity to archive much larger volumes of data. Now that the idea of cheap, easy archiving and copying was a reality, it

became necessary to conceive of ever more sophisticated ways to keep track of the large volumes of information firms now wanted to keep track of. Through this channel, the introduction of xerography may have indirectly led to the personal computer and the internet. Xerox played another key role in that process by investing the profits earned by early Xerox machines, such as the 914, in the Palo Alto Research Center which developed many of the component elements of the modern computer.

Innovation, it seems, begets innovation, and the profits from yesterday's triumphs fund tomorrow's explorations. The cycle of creative destruction means that after a new product exhausts its value-enhancing potential and its profitability disappears, the competitive zero-profit equilibrium takes hold until the next innovation supplants all the current competitors. Xerox and its now ubiquitous brand is a classic example of this process, from start to finish.

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