Managing Technology Risks

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Technological changes are responsible for both the creation and destruction of industries. In the face of wrenching changes in technology, some industries die while others are born. Quite clearly, a firm's competitiveness is significantly influenced by its ability to adjust to new technologies. Since technological evolution and innovation have a profound impact on the destinies of firms, understanding this process is very important.

Technology can have two types of impact. Internally, it can help an organization to make something more efficiently and pass on the cost savings to customers. Externally, it can help the company to offer an innovative product that customers value. In the first category fall product innovations which refer to work done to improve the product. Such innovations can be radical, such as the Sony Walkman or incremental, such as adding new features to a colour television set. In the second category are process innovations which aim to make the manufacturing process more efficient through automation, simplification, better process control, lower energy consumption, etc. The float glass process is an excellent example.

Increasing speed of innovation

The pace of technology development has increased significantly in recent times. If we look back at the industrial revolution, innovation cycles were long and it took some time before one technology gave way to another. Today, the speed at which innovation is taking place is breath taking. Unless organizations can foster a culture in which new ideas are encouraged and commercialized rapidly, they may find themselves being overtaken by faster innovators.

Innovation cycles are becoming shorter mainly because of the growing importance of knowledge inputs as opposed to physical capital. People with good ideas and the brain power can innovate as the need for huge amounts of physical capital has been obviated. A related factor is the availability of venture capital. Today, money is available even for graduates fresh out of college provided they have good ideas.

Why technology threatens established firms

Many established firms have fallen by the wayside after failing to give technology risk the importance it deserved. It is not that they did not invest sufficiently in research and development. More often than not, it has been their business philosophy and deep rooted culture that have acted as stumbling blocks. According to Clayton Christensen, a Harvard Business School Professor and a renowned scholar in the area of technology management, many established firms are so much glued to the needs of existing customers that they overlook what other segments are looking for. Moreover, when overheads are high, there is a tendency not to invest in technologies, which may not have great revenue or profit potential in the short run. On the other hand, smaller, nimbler rivals for whom even small markets can be quite lucrative come up with disruptive innovations that dislodge well entrenched market leaders. In other words, the concept of Customer Relationship Management, as practised widely today, can be extremely counter productive in fast changing industries where new customer segments with different requirements evolve rapidly.

Understanding the innovation process

Peter Drucker[1] describes innovation as "the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth." He refers to innovation as "the effort to create purposeful focused change in an enterprise's economic or social potential".

Technological evolution in the typewriter industry

Remington No. 1, the first ever typewriter offered to the general public in 1874 was based on the invention of a former newspaper editor, Christopher Latham Sholes. The typewriter had a speed of 57 words per minute. Initially, it used narrow wooden keys that connected to the type hammers by means of wires. Later, Sholes made improvements, replacing the wires with telegraph – like keys. He developed a series of models, each, a minor improvement over the previous, and sold the concept to Philo Remington, who agreed to be the exclusive manufacturer of the machine. The Remington No.1 had only upper case letters. Due to the high price and poor performance, consumer acceptance was slow. Remington however, continued to improve the product, selling some 4000 mechanisms by 1877. The No.2 launched in 1878 had shift keys and lower case alphabets. During its lifetime, it sold 100,000 units. As the market grew and the typewriter became an integral part of offices, other players entered the industry. By 1886, some 50,000 typewriters of all makes had been produced and by 1888, Remington itself was turning out some 1,500 machines each month.

As Sholes' patents expired, a number of firms entered the industry between 1885 and 1890. Fraz X Wagner came up with a new typewriter design in which the type arms swung out and struck the paper front and centre. This enabled the typist to correct mistakes immediately. John T Underwood and his father, bought the design from Wagner and the new machine which went into production in 1895 was a big success. Underwood continued to develop new models. The Model 5 launched in 1899 was quite sophisticated with a visible type, a light touch, a tab function, quiet operation and a design that made corrections easy. It became a run away success. Remington was thrashed soundly and by 1920, Underwood was selling as many machines as all of its rivals combined.

In 1933, a relatively minor player in the industry, Electrostatic Typewriters Inc was purchased by IBM to gain access to keypunch technology for its record-accounting and tabulating machines. IBM received many orders from the government during the war enabling it to understand the technology rapidly. Electric machines were superior in terms of print uniformity, quality of copies and physical stress. In 1950, electrics had only 10% of the market but this had increased to 50% by 1965. By 1970, manual typewriters had a market share of only 24%. IBM took control of the market with a share of 74% of the high end full features electric market by 1967.

The IBM Magnetic Tape Electric, introduced in 1964, combined electric typewriter technology with digital technology to make text editing possible for the first time. By the early 1970s, stand-alone word processors had begun to replace standard office typewriters. Wang, Xerox, Exxon, ITT, AT&T and Olivetti all attempted to develop sophisticated machines for text processing applications. By 1975, 200,000 word-processing devices had been sold and by 1986, this number had swollen to 4 million.

The arrival of the personal computer marked the next wave of disruptive innovation. By 1981, an estimated 500,000 personal computers had been sold to businesses. The introduction of the IBM PC that year was a landmark event. IBM's open architecture and its decision to make operating system information available to the public attracted applications software developers. The versatility of the PC allowed people to write and edit text, run spread sheets and create graphics, facilities not available on type writers and older word processors. By 1987, PCs outsold world processors by 4.5 times. Today PCs have become indispensable at the work place as productivity enhancement tools. Typewriters are to be seen nowhere.

In his book "Innovation and Entrepreneurship", Drucker has listed seven sources of opportunity for innovative organizations. Four are internal to the enterprise and three are external. In order of increasing difficulty and uncertainty, they are as follows:-

- *Unexpected success or failure* - Understanding the reasons for the unexpected success or failure of a product generates opportunities to innovate.
- *The incongruity between what actually happens and what is supposed to happen* - If things are not happening as they should, there is scope to innovate.
- *The inadequacy in an underlying process that is taken for granted* - If a process is inefficient or suffers from a big gap, there is scope to innovate.
- *The changes in industry or market structure that catch everyone by surprise* - There is potential to innovate by developing products for new fast growing segments.
- *The demographic changes caused by wars, medical improvements and even superstition* - Such changes result in new wants and new lifestyles that have to be satisfied by new products.
- *The changes in perception* - By changing the common perception of people, new moods can be created resulting in new needs.
- *The changes in awareness caused by new knowledge* - New knowledge can be used to develop innovative products.

[1] *Harvard Business Review, November – December, 1998*

Drucker also makes the point that it is social innovations like advertising and banking that have made more impact than technological innovations. In this paper, however, we focus on technological innovations.

Sustaining and disruptive technologies

One way to look at innovations is in terms of their relationship to the existing capabilities of leading industry players. According to Utterback, an MIT professor and another renowned scholar in the area of technology management, innovations can either enhance or destroy existing competencies. Competence enhancing innovations may come from existing players as well as outsiders but competence destroying innovations nearly always come from outsiders.

Christensen[2] draws an important distinction between sustaining and disruptive technologies. The distinguishing feature of sustaining technologies is that they look at parameters which are important to existing customers and aim to produce improvements with respect to these parameters. While the improvement may be incremental or radical in nature, the new technology compares very favourably with the existing technology, and offers a superior value proposition to existing customers. On the other hand, disruptive technologies bring a value proposition which cannot be compared to existing technologies. Products based on disruptive technologies are typically inferior in terms of performance but are often cheaper, simpler, smaller and frequently more user friendly, when compared to existing products.

The point to note is that established companies typically do well in developing sustaining technologies but it is new entrants who often come up with disruptive technologies. It was a brash upstart called Microsoft which developed the operating system for PCs and not established computer companies like IBM or Digital Equipment. Xerox was slow in responding to the emergence of small table top copiers. Traditional leaders in the excavator business like Bucyrus-Erie were easily overtaken by companies like Caterpillar when hydraulics technology emerged. Christensen's views are shared by Utterback[3]: "Looking for industry-shattering innovation among the current players in an industry might be misdirected effort; most of the innovations occur in unexpected places, and when they do, the current leaders often react in inappropriate ways and lose their dominant positions in the industry."

Christensen introduces the concept of Value network, which he defines as the context in which a firm identifies and responds to customer's needs and solves problems, procures inputs, reacts to competitors and strives for profit. Different value networks attach different degrees of importance to different attributes. Within a value network, the way a firm perceives the value of a new technology is shaped by its past choices of markets. In the case of mainframe computers for example, disk drive performance is judged by its capacity, speed and reliability. In the case of lap top computers on the other hand, performance is judged in terms of ruggedness, low power consumption and small size. This is precisely why, disk drive manufacturers so successful in the main frame segment failed to penetrate the PC market.

Christensen points out that established firms competing within a value network develop capabilities, organizational structures and cultures that meet the value network's specific requirements. This also leads to a different cost structure. Again, the computer industry is a good example, Vertical integration, customised products and lower volumes have created a high cost structure for mainframe computer manufacturers like IBM. On the other hand, outsourcing, higher volumes and standardized configuration have resulted in lower cost structures for PC manufacturers like Dell. A company's cost structure influences the way it perceives the attractiveness of a customer segment. Since disruptive technologies typically create low margin products to start with, established companies often ignore them, especially if customers are reluctant to accept them due to their lower initial performance.

Understanding the significance of new technologies

Many companies do not correctly assess the impact of a new technology. Bell Labs for instance did not think it necessary to apply for a patent covering the

[2] *Read his exciting book, "The Innovator's Dilemma", for a more detailed understanding of disruptive technologies.*

[3] *Read his excellent book, "Mastering the Dynamics of Innovation"*

use of laser in telecommunications. Only later, did it realise what a powerful combination, laser and fiber optics made. Inventors, owing to their highly technical orientation often fail to appreciate how the technology will be used. Marconi, the inventor of the radio felt that it would be mainly used between two points where communication by wire would be impossible. He identified users such as shipping companies, the navy and newspapers, but failed to consider the possibility of communicating to several people at the same time. Thomas Watson Sr looked at the computer only as a tool for rapid scientific and data processing calculations. So, he grossly underestimated the demand for computers till his company accidentally found that computers could be used effectively in pay roll applications.

One of the difficulties associated with a new

Evolution of glass technology

Glass is one of the most useful materials in the world today. It is used for making a range of products including jars, containers, windows, windshields and eyeglasses. Made chiefly from silica sand, soda ash and limestone, glass was first made in the middle east around 3000 BC. In the beginning, glass melting furnaces were small, produced little heat and the process was slow and costly. Consequently, glass remained a luxury in ancient times.

In the first century, an unknown person discovered the blow pipe, which made glass production faster, easier and cheaper. During the Roman empire, glass manufacturing not only flourished but also spread to other countries. Mass production made glass an affordable product. Glass manufacturing developed in Venice during the time of the crusades ((AD 1096-1270). By the late 1400s and early 1500s, glass making had become important in Germany and many North European countries. Glass making became important in England during the 1500s. The first factory in what is now the United States was set up in 1608 in Virginia.

Until the 1880s, the flat glass industry was made up of small producers employing highly skilled artisans. Glass manufacturing sites were located near fuel sources and production processes were predominantly manual. The cylinder glass process resulted in significant improvements in both productivity and quality, though the glass remained wavy and had some imperfections. In 1903, the American Window Glass Company introduced a cylinder-blowing machine that eliminated the need for skilled labour. The Colburn sheet-drawing machine, which appeared in 1917 and the several incremental improvements in the following decades continued to lower costs and the need for skilled labour.

In 1861, the Siemens brothers of Germany developed a gas fired furnace. Preheating of gas and air before entering the fire chamber improved the thermal efficiency. The cleaner fuel eliminated the smoke and ash associated with wood and coal furnaces. By 1880, Siemens had also introduced continuous melting tanks. Workers could add ingredients at one end of the melting tank while molten glass was taken out of the other end for casting. The traditional method had involved mixing and melting at night and pouring and working during the day. In the new process, quality and efficiency improved while the need for skilled labour reduced. The cleaner fuel eliminated the smoke and ash that were associated with wood and coal furnaces. The continuous tank however, involved high capital costs.

Till the 1880s, plate glass was cast on to metal tables, held in an annealing kiln for days before grinding and polishing. In the 1880s, the idea of using a tunnel annealing kiln was introduced. Tables were joined together and passed through a long tunnel. The kiln effectively converted the batch process into a continuous process.

Hand casting (between continuous mixing /melting and continuous annealing) and grinding and polishing continued to be production bottlenecks. The Bicheroux process combined casting and rolling to cut production time and produce a more uniform thickness. In 1922, UK based Pilkington Brothers, tied up with Ford and developed a process for casting a continuous ribbon of plate glass through rollers on to a conveyor that passed through the tunnel kiln. A sheet of polished plate glass that needed 10 days to make in 1889 could be produced in 3 days in 1923. Pilkington also developed machinery for grinding and polishing both sides of a continuous glass ribbon simultaneously.

In the 1950s, Pilkington developed the float process. The raw materials, silica sand, calcium oxide, soda and magnesium were properly weighed and mixed and then charged into the furnace maintained at around 1500^{0}C. Molten glass flowed out of the furnace into a bath of molten tin. The contact surface between the glass and tin was perfectly flat. When it left the bath, the molten glass moved into an annealing chamber, where cooling took place at controlled temperatures. The glass after undergoing quality checks was washed and cut into sheets and kept in stacks for transport.

Today, the process right from the batching of raw materials to cutting and stocking is fully automatic and computerised. The float process has resulted in smooth glass of uniform thickness, coming straight from the oven. It has improved quality and reduced the need for grinding and polishing. Labour and energy costs have fallen drastically. The process has converted plate glass making from a labour intensive craft industry into a highly efficient and automated industry.

Senior Pilkington executives have admitted that had they been fully aware of the cost of developing float glass technology, they might not have tried it. Pilkington which was a private firm virtually bet the company on the process. Had it been a public company, it is doubtful whether the board would have given the green signal for the development efforts.

Today, the float glass process is the norm in most countries inspite of the high capital expenditures incurred, because of its high efficiency. It accounts for more than 90% of the plate and sheet glass manufactured. Only in developing countries with small markets and limited capital, have older technologies survived.

technology is that it tends to be primitive when first developed. A series of improvements is often necessary to make it fit for a range of commercial applications. Indeed, the full potential of a new technology can sometimes be exploited only decades later. Even though the telephone has been around for more than 100 years, only now have applications like voice mail and data transfer emerged. Who knows what new applications may still emerge? Aspirin, one of the most widely used drugs in the world has been around for 100 years, yet its efficacy in reducing the incidence of heart attack due to its blood thinning properties was discovered only recently.

A frame work for managing technological risk

When do new technologies emerge? What can organisations do to be prepared for such an eventuality and make sure they are not dislodged by new entrants?

To start with, companies should watch out for situations where customer needs are more than satisfied and new features do not provide much value to the customers. According to Michael Porter, the basic premise of differentiation is to provide something extra that the customers value and charge a premium. If customers do not value the additional features, differentiation as a competitive strategy will not be effective. So, if a new technology fares relatively low on some of the currently accepted attributes but scores heavily on a new attribute, it has the potential to unseat the older technology. Thus, in the disk drive industry, capacity became less important and factors such as physical size and reliability became the important attributes. So, manufacturers who continued to invest in improving disk drive storage capacity lost out.

The key issue in managing a radical innovation is the need for a new mindset. Successful innovators often have lesser resources and no particularly great strengths in scientific or technological discovery, while established players, are not short of financial muscle or talented manpower. But, the successful innovators have the right mindset They worry less about what the technology can do and instead look for customers who will be happy with the current performance levels. Thus a strong, marketing orientation characterised by a zeal to go out, understand customers and tap hitherto neglected segments is a key success factor in managing innovations.

Companies must also strike the right balance between incremental and radical innovation. Existing product lines are important because they provide the cash flows needed to finance the development of future products. At the same time, break through initiatives must be encouraged even if they are not very profitable to start with. Indeed, the challenge for management is to find the right balance between incremental improvements and new and unproven technologies. Large established firms that want to stay the course must be prepared to shift their strategic and competitive postures from time to time. They have to regenerate and renew their businesses constantly.

Managing radical and sustaining technologies under the same roof is a challenging task for most organizations. According to Michael Tushman and Charles O' Reilly[4], "The contradictions inherent in the multiple types of innovation create conflict and dissent between the organizational units- between those historically profitable, large, efficient, older, cash-generating units and the young, entrepreneurial, risky, cash-absorbing units. The management team must not only protect and legitimize the entrepreneurial units, but also keep them physically, culturally and structurally separate from the rest of the organization." So, it often makes sense to keep new product development teams away from the main organization and its associated bureaucracy. But at the end of the day, it is an organization's commitment to innovation and how it encourages its employees to innovate, inspite of occasional failures, that determines its success or failure in technology risk management. ■

Reference # 15-01-12-11

[4] *In their book "Winning through innovation".*