## A Strategic Approach to Managing Technology Risks

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**Understanding technology risk**

Technological changes are responsible for both the creation and destruction of industries.  In the face of sweeping changes in technology, some industries die while others are born.  Quite clearly, a firm's competitiveness is significantly influenced by its ability to understand  and embrace new product or process technologies.

Introducing technological change is risky because it brings with it a high degree of uncertainty.  Understanding the nature of this uncertainty, especially the obstacles to the acceptance of the new technology, is a tricky issue.  Between technical feasibility and commercial viability is a period  of suspense.

Excessive caution and haste are both undesirable in the context of new technologies.  Sometimes, companies commit themselves to a new technology too fast and burn their fingers.  In other cases, they wait and watch while another company comes up with a new technology that puts them out of business. So, even the most seasoned managers have problems evaluating the potential of a new technology.

In this paper, we make an attempt to understand the nature of technological innovations and develop a framework to manage technological risks.

**The growing pace of innovation**

Earlier, innovation cycles were quite long. This was the case with water power, textiles and iron in the late 18th century; steam, rail and steel in the mid-19th century; and electricity, chemicals and the internal-combustion engine at the turn of the 20th century.  Another innovation cycle led by oil, electronics, aviation and mass production, is now drawing to a close. Current indications are that a fifth industrial revolution—based on semiconductors, fibre optics, genetics and software—is not only well under way, but even approaching maturity.  Quite clearly, innovation cycles have shortened, from 50-60 years to around 30-40 years.  Unless organisations can foster a culture in which new ideas are encouraged and commercialised rapidly, they may find themselves being overtaken by faster innovators.

Why have innovation cycles become shorter ? Probably the most important reason is the growing importance of software and knowledge inputs as opposed to hardware and  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. Unlike banks, venture capitalists (VCs) give less importance to things like collateral and more to the business potential.  So, it has become easier for first generation entrepreneurs to convert their ideas into up and running businesses. Another important reason for the faster pace of innovation is the speed at which information is being disseminated, due to information technology in general, and the internet in particular.  This enables ideas to flow freely and encourages new entrepreneurial initiatives.

**Managing Innovations**

There are broadly two types of innovation.  *Product innovation* refers to work done to improve the product.  Some product innovations are truly radical, such as the Sony Walkman.  Others are incremental, such as adding new features to a colour television set. *Process innovations* aim to make the manufacturing process more efficient through automation, simplification, better process control and lower energy consumption.  Normally, product and process innovations are interdependent.  In the early stages of the product life cycle, product

innovations tend to be rapid. As the rate of product innovation decreases, it is common to observe a faster rate of process innovation. But the relative importance of product and process innovation depends on the nature of the industry.

What can organisations do to encourage and nurture an innovation driven environment? In his 1985 book "Innovation and Entrepreneurship," Peter Drucker has listed seven sources of opportunity for innovative organisations.

In order of increasing difficulty and uncertainty, they are:

•The unexpected success that makes a company happy, but is rarely dissected to see why it occurred.

•The incongruity between what actually happens and what was supposed to happen.

•The inadequacy in an underlying process that is taken for granted.

•The changes in industry or market structure that catch everyone by surprise.

•The demographic changes caused by wars, medical improvements and even superstition.

•The changes in perception, mood and fashion due to the ups and downs of the economy.

•The changes in awareness caused by new knowledge.

In his interesting article, "Bringing Silicon Valley inside,"[3] Gary Hamel has drawn various insights from the success of Silicon Valley and explained how innovations can be encouraged. Hamel draws a distinction between stewardship, (safeguarding existing skills and assets) and entrepreneurship, (creating something new). He feels that for innovations to take place, the emphasis must shift from resource allocation to resource attraction. What Hamel emphasises is that good ideas should be encouraged with support in the form of capital and human resources. Like Christensen, he explains how traditional capital allocation processes are unsuited for radically new businesses: "Resource allocation is well suited to investments in existing businesses. If the goal is to create new wealth, something much more spontaneous and less circumscribed is required – something much more like resource attraction… Resource allocation is about managing the downside. Resource attraction is about creating the upside." Hamel feels that ideas flourish in Silicon Valley for three reasons. People are clear that only innovations can create new wealth, and not improvements in existing processes. In the Valley, a budding entrepreneur can try his luck with several VCs and tie up the funding. Lastly, there is no prejudice about who can or cannot succeed. So, even brash upstarts with good ideas are well received by VCs. Hamel agrees with Christensen that innovative ideas and technologies/business models cannot be filtered through traditional financial screens. In his article, Hamel quotes Steve Jurvetson, one of the leading VCs in the valley: "The business plan is not a contract in the way a budget is. It's a story. It's a story about an opportunity, about the migration path and how you are going to create and capture value. I never use Excel at work. I never run the numbers or build financial models. I know the forecast is a delusional view of reality. I basically ignore this. Typically, there are no IRR forecasts or EVA calculations. But I spend a lot of time thinking about how big the thing could be." Hamel adds: "In most companies, the goal of capital budgeting is to make sure the firm never ever makes a bet-the-business investment that fails to deliver an acceptable return. But in attempting to guarantee that there's never an unexpected downside, the typical capital budgeting process places an absolute ceiling on the upside. Dollars lost are highly visible but dollars forgone are totally invisible."

**Commercialising new technologies**

Successful technology management is all about bringing a new concept to the market in the most efficient way. To commercialise an idea successfully, a number of different stages[4] must be completed, each more difficult than

its predecessor. Not only must each of these stages be completed successfully, but adequate resources mobilised to facilitate transition from one stage to the next.

• *Imagining*. Developing the initial insight about the market opportunity for a particular technical development.

• *Incubating*. Nurturing the technology sufficiently to gauge whether it can be commercialised.

• *Demonstrating*. Building prototypes and getting feedback from potential investors and customers.

• *Promoting*. Persuading the market to adopt the innovation.

• *Sustaining*. Ensuring that the product or process has as long a life as possible in the market.

The first three stages obviously cannot be managed like an ordinary business with tight controls. So they have to be fostered and nurtured in an environment which is culturally quite different from normal corporate settings.

Chan Kim and Renee Mauborgne (Harvard Business Review, September-October 2000) offer a useful framework for commercialising technological innovations. They feel that organisations must address three important issues. What is the likelihood that customers will be attracted to the new technology? What is the price that will attract the largest number of customers? Will the new technology evolve into or help in building a profitable business?

Successful innovators focus on how the new product or service will affect customers. They look at the various stages of customer experience like purchase, delivery, use, maintenance and disposal. They also consider the utility of the product in terms of environmental friendliness, convenience, simplicity and customer productivity. In other words, they orient product development activities towards the customer rather than the technology.

The price chosen by the innovator has to attract and retain a sufficiently large number of customers. Innovations very often compete with other products which may look quite dissimilar but perform the same function. What is important here is how people will compare the new product with other very different-looking products and services. The price level will also depend on the ease of imitation. If the product is difficult to imitate or well protected by patents, a high price is possible. On the other hand, if imitation is easy, a low price becomes essential.

Successful innovators understand the importance of generating positive cash flows as quickly as possible. They generate profits not by raising price but by keeping costs tightly under control, consistent with the chosen price level. They improve materials selection, simplify design processes and improve manufacturing efficiencies to cut costs. They may also consider strategic outsourcing of non core activities. Moreover, innovators compensate for their lack of technological capabilities in some areas by partnering and forming alliances. In spite of all these moves, if the price is still high and beyond the reach of target customers, they look at options such as leasing or renting the product on a time share basis, which are more appealing to customers.

### How new technologies threaten established firms

When do new technologies emerge that overtake existing technologies? What can organisations do to be prepared for such an eventuality and make sure they are not dislodged by new entrants? A framework developed by Clayton Christensen of Harvard Business School provides a good answer. A proven technology improves over a period of time to produce rates of performance improvement well beyond customer needs. When customer needs are more than satisfied, the differentiated offerings of existing players lose their meaning[5]. Under such circumstances, 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, smaller disk drives began to gain popularity.

Many established firms are overtaken by new technology, not because they do not invest sufficiently in research and development, but because their business philosophy and deep rooted culture act as stumbling blocks. As Christensen has explained, they 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 take seriously new technologies with little revenue or profit potential in the short run. On the other hand, for smaller nimbler rivals, even small markets can be quite lucrative. Consequently, smaller companies who are not glued to the existing customers and who have an open mind, come up with innovations that dislodge well entrenched market leaders. In his book, "Mastering the Dynamics of Innovation," James Utterback describes the extent to which established players go to resist all efforts to understand new technological developments and instead strengthen their commitment to the older products: "This results in a surge of productivity and performance that may take the old technology to unheard-of heights. But in most cases this is a sign of impending death… Industry outsiders have little to lose in pursuing radical innovations. They have no infrastructure of existing technology to defend or maintain… Industry insiders… have huge investments in the current technology; emotionally they and their fortunes are heavily bound up in the status quo and from a practical point of view, their managerial attention is encumbered by the system they have - just maintaining and marginally improving their existing systems is a full-time occupation."

Often the impact of an innovation depends on complementary inventions. Many new components may be needed to develop a larger technological system that can fully exploit the new technology. Laser needed fibre optics, to be used in telecommunications. The computer industry could take off only after the integrated circuit had been developed. Established companies are handicapped by the tendency to compare the new technologies with the older technologies they are going to replace. They overlook the fact that the cumulative effect of several improvements within a technological system over time can sometimes be immense. Consequently, their commitment to new technologies is often inadequate             .

Many companies fail to assess the impact of a new technology. Bell Labs for instance did not think it necessary to apply for a patent covering the 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 assess correctly how the technology will be used.Marconi, the inventor of the radio is a good example. He felt that it would be used between two points where communication by wire would be impossible. Potential users he identified were shipping companies, the navy and newspapers. Marconi, however, failed to consider the possibility of communicating with several people at the same time.

The full potential of a new technology is sometimes recognised only decades later. Take the case of the telephone. Even though the telephone has been around for more than 100 years, only now have applications like voice mail and data transfer emerged. Identifying uses for new technologies is very difficult. Aspirin, one of the world's most widely used drugs 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.

**Sustaining and disruptive technologies:**

One way to look at the impact of innovations is in terms of their relationship to the existing capabilities of leading industry players. According to Utterback, innovations can either enhance or destroy existing competencies. Generally, competence-enhancing innovations may come from existing players in the industry as well as outsiders, but competence destroying innovations nearly always come from outsiders.

Christensen's conclusions are similar to those of Utterback. He draws an important distinction between sustaining and disruptive technologies. Sustaining technologies concentrate on parameters which are important to existing customers and aim to produce improvements with respect to these parameters. The new technology compares very favourably with the existing technology, with superior value proposition for existing customers. On the other hand, disruptive technologies bring a value proposition different from that provided by 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.

Utterback (Managing the dynamics of innovation) agrees with Christensen: "At the time an invading technology first appears, the established technology generally offers better performance or cost than does the challenger, which is still unperfected." But disruptive technology works, because as marketing guru, Theodre Levitt, reasons, beyond a point, adding features based on customer surveys  may be counter-productive.  Give a customer a value-for-money product, with an acceptable quality or performance level instead of adding more and more features, that are valued less and less by customers, to existing products.

The important point to note is that established companies tend to 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 commercialised 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. As Utterback puts it: "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."

Existing firms are usually reluctant to embrace disruptive technologies for various reasons.   They often promise lower margins because they are cheaper products.  Very often, these technologies are accepted by small insignificant market segments rather than by mainstream customers, who reject the new technology because of its relatively inferior performance, at the time of introduction. Established companies approve investments in a rational way, making an estimate of the market size and working out the expected returns.  Unfortunately, in the case of disruptive technologies, market data is hard to come by and making financial projections is difficult if not impossible.

Christensen introduces the concept of *Value network*, which he defines as the context in which a firm identifies and responds to customer needs and solves problems, procures inputs, reacts to competitors and tries to learn.  He argues that within a value network, the way a firm perceives the value of a new technology is shaped by its past choices of markets.  Different value networks  attach different degrees of importance to different attributes.  In the case of mainframes 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.

Christensen points out that established firms competing within a value network develop capabilities, organisational structures and cultures that meet the value network's specific requirements.  This also leads to a different cost structure. Take the case of the computer industry. Vertical integration, customised products and lower volumes have created a high cost structure in the case of mainframe computers.  On the other hand, outsourcing, higher volumes and standardised configuration have created lower cost structures for PC manufacturers.  Their existing cost structure also influences the way companies perceive the attractiveness of a customer segment.  Since disruptive technologies often create low margin products to start with, established companies often bypass them, because their overheads tend to be high.

**A framework for managing disruptive technologies**

Technological performance often overshoots market requirements.  Consequently, today's under-performing technology may meet the needs of customers tomorrow.  On the other hand, technologies which perform satisfactorily today may over-perform tomorrow and customers may not be willing to pay for this over performance.  As Christensen  puts it[6], "In their efforts to stay ahead by  developing competitively superior products , many companies don't realize the speed at which they are moving up-market, over satisfying the needs of their original customers as they race the competition towards higher-performance, higher-margin markets.  In doing so, they create a vacuum at lower price points into which competitors employing disruptive technologies can enter." Utterback (Mastering the Dynamics of Innovation) makes a similar point: "Failing firms are remarkably creative in defending their entrenched technologies, which often reach unimagined heights of elegance in design

and technical performance only when their demise is clearly predictable."

How can managers identify the real worth of a new and disruptive technology? Usually, they can recognize it only in retrospect. Yet, the fact that disruptive technologies are developed by new firms or by large enterprises entering a new business or by spin-offs of established competitors, offers them some clues. Since the formation of new firms is a fairly visible process, studying the type of products they develop or launch can be a very useful source of information about technological innovation.

A fresh approach is necessary for managing disruptive technologies. Management according to detailed plans and budgets is difficult in the case of such technologies. Applying conventional investment appraisal processes can also be counter-productive. Instead, companies must be prepared to go through a process of discovery with plans for learning instead of rigidly implementing preconceived strategies. As Christensen[7] puts it: "By approaching a disruptive business with the mindset that they can't know where the market is, managers would identify what critical information about new markets is most necessary and in what sequence that information is needed. Project and business plans would mirror these priorities, so that key pieces of information would be created and important uncertainties resolved, before expensive commitments of capital, time and money were required…"

Thus, the key issue in managing a radical innovation is the need for a new mindset. Very often, successful innovators are the ones with less resources and no particular strengths in scientific or technological discovery. On the other hand, established players who are beaten lack neither financial muscle nor talented manpower. But successful innovators are blessed with the right mindset. They worry less about what the technology can do and instead look for markets which 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 radical innovations.

Successful companies should create small empowered teams to dabble in new technologies, encourage them to come to the market quickly and keep making performance improvements as feedback from customers pours in. Since entrenched processes and values stand in the way of change, a separate organisation for which even small business volumes are acceptable, is a more practical arrangement than grandiose attempts to change the entire company's culture. According to Richard N Foster (Innovation: The Attacker's Advantage), "the attacking and defending ought to be done by separate organizations."

Utterback[8] has drawn the following conclusions about the general pattern of innovations. Discontinuous innovations in assembled products almost always seem to come from outside the industry. Discontinuous innovations in non assembled products may come from inside or outside the industry. Discontinuous changes in process in the case of homogeneous products are quite likely to come from established firms or their equipment suppliers. When discontinuities broaden a market, newcomers are likely to lead the way. When they do not broaden the market or create a new niche, existing players will be better placed. Innovations that destroy established core competencies almost always come from outside while those that enhance these competencies may come from inside the industry. Established companies need to keep these points in mind if they do not want to be unseated by new technologies.

## Conclusion

When it comes to successful innovation, technology by itself is not the crucial factor. Technology must be considered together with market conditions and human factors. Companies have to be on the look-out for emerging market segments. They must also understand why there is resistance to the acceptance of new ideas.

For established companies, existing product lines are important because they provide the cash flows so vital for financing the development of future products. At the same time, they cannot resist new initiatives. Indeed, the challenge for management is to find the right balance between incremental improvements and new and unproven technologies.

Incremental improvements on an ongoing basis demand equal emphasis on product and process design, which should be closely integrated. Regularly measuring product and process performance and tapping all the potential opportunities for improvement are important. Companies should look for cost reduction through better use of materials, energy and labour, reduction in number of products, and product and process simplification. At the same time, they must develop the core capabilities which will become critical in the future. This means they should be prepared to shift their strategic and competitive postures from time to time by regenerating and renewing their businesses.

While it is difficult to anticipate technological discontinuities, efforts must nevertheless be made to scan the environment. Firms often make the mistake of looking in the wrong places. They need to look more carefully at obscure, and unconventional sources of competition. Moreover, companies must strike the right balance between focus and diversification when developing technologies. If a company is highly focussed on a few competencies, it runs the danger of becoming vulnerable to a radical innovation based on a different set of competencies. On the other hand, if the firm tries to develop too broad a set of competencies, it may be spreading its resources too thin. In other words, technology risk management is a tightrope walk. And the chances of falling off the rope are high for most players. The ones who don't fall off ultimately emerge as the winners.

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[3]         Harvard Business Review, September-October 1999

[4]         *Framework developed by Vijay Jolly, formerly of IMD, Lausanne, Switzerland.*

[5]        As the famous management guru Porter has mentioned, 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

[6]        *The Innovator's Dilemma*

Mastering the Dynamics of Innovation