High technology products have certain salient characteristics that differentiate them from low technology consumer products. The marketers of the products of the latter type may adjust their marketing strategies to reflect relatively unchanging technological conditions. High technology companies, however, must recognize that both technological and market conditions are rapidly changing. This dynamic environment necessitates a greater consideration of both marketing- and technology-related aspects. One of the major objectives of this paper is to explore the context in which the terms ‘high technology’ products/markets/industries have been used in the extant literature. Because of the focus of earlier studies on some specific elements and stand-alone issues in this area, this paper fills the gap for a broad overview of the marketing-specific issues in high technology area and relates it to the lessons drawn from practice.

The theoretical results illustrate the following:
- Several definitional viewpoints and characterizations of high technology industries exist in the literature, namely (i) uncertainty, (ii) input-based, (iii) output-based, (iv) increasing returns and network externalities, and (v) techno-paradigm.
- One of the more popular views, uncertainty, characterizes the uncertainty in high technology industries in terms of (i) market, (ii) technology, and (iii) competition.
- Another popular techno-paradigm view refers to the set of all industries which conform to a certain set of paradigmatic trends such as enormous R&D expenditure, predatory competition, and substantial diversification and innovation waves.
- The high technology markets must focus on both demand-side and supply-side marketing. Several examples from the literature contradict the popular notion that the superior product will win out in the marketplace.
- A critical aspect particularly relevant to the high technology products diffusion is that there might be ‘cracks’ or ‘gaps’ in bell-shaped adoption curve (e.g., innovator-early adopter and early majority-late majority) also known as ‘chasm’ or the ‘valley of death’ for high technology products.
- Newer and different marketing research techniques, such as census approach, lead user study, and outcome-based techniques are more relevant for high technology products.

The case study discussed in the paper suitably supports the theoretical results illustrating the following situations:
- A majority of the small-scale grey iron foundry units in India employ cupola furnace for melting using coke as fuel with inefficient combustion and higher energy consumption.
- The Energy and Resources Institute (TERI) set up a demonstration plant consisting of an energy-efficient cupola design called the divided blast cupola (DBC) at a foundry unit in Howrah. After successful demonstration, the challenge was to replicate the technology among other foundry units.
- The major barriers to adoption were: (i) prevailing practice, (ii) limited in-house technological capability, and (iii) investment.
- Future work by TERI envisages the need for adopting a philosophy of vendor development and conducting formal marketing research study.
High technology has several popular connotations. For the enthusiasts, high technology is the epitome of national competitiveness which will usher in unprecedented opportunities for economic growth and competitive advantage. For the skeptics, high technology is nothing more than the myriad electronic devices and gadgets which move on and off the store shelf with remarkable speed. The primary product characteristics behind these connotations are rapid change and extreme complexity because of which high technology is frequently associated with speedy product development and hyper-competition. The term high technology products is generally used for any product, ranging from sports shoes to RFID (Radio Frequency Identification), whose functioning is beyond the reach of common knowledge. The definition of high technology products/markets has been proposed in different contexts such as projecting employment growth to formulating policy proposals to enhance national competitiveness (Diwan and Chakraborty, 1991). Therefore, the issues of marketing of high technology products are complicated and challenging due to the peculiar characteristics of high technology products which are discussed in later sections.

Some researchers have addressed issues related to high technology marketing. Roberts (1992) proposes that the success of high technology companies depends upon many factors comprising technological and marketing influences at the time of or soon after company founding. Many marketing-related factors are associated with the later success of emerging companies, including visible marketing organization and practices, and an accurate understanding of customer needs and competition. Ziener (1992) proposes a decision support system to aid scenario construction for sizing and timing marketplaces in high technology industries. Their methodology focuses on two important issues related to marketplace dynamics: (i) recognition of the customer for the product class under consideration, and (ii) the transition of the marketplace life-cycle for the product class from ‘emerging’ to ‘maturing.’ Steele (1995) proposes an economic theory of technological products as a mathematical extension of neo-classical economics in which the technological performance of a product is allowed to vary. Linton (2004) presents a model for forecasting the likely market size and demand for an early-stage emerging process technology. The method takes into account markets, supply, demand, supply/demand gap, pricing, government policy, corporate strategy, and value of intellectual property. Stewart, Craig and Mullarkey (2003) propose that the organizations should encourage different and heterogeneous combinations of information processes to succeed in turbulent environments which characterize marketing of high technology products. Meade and Rabelo (2004) introduce a quantitative approach to help high technology firms to understand their position in the technology adoption life-cycle using chaos and complexity theories. Im and Workman (2004) examine the mediating role of new products and marketing programmes creativity between market orientation and new products success in the context of high technology. Strebel, Erdem and Swait (2004) focus upon the use of information channels during the purchase process for high technology durable goods. They examine how the perceived quality of information as well as demographic and other consumer characteristics affect consumers’ information channel choice behaviour.

Some other studies have attempted to address the issues of high technology marketing from a conceptual standpoint. Moriarty and Kosnik (1989) posit that the world of high technology is characterized by unusually high levels of market and technological uncertainties which affect marketing strategies and tactics. Their pragmatic prescriptions for marketers of high technology include the expansion of skill set, abandoning of less relevant knowledge, building of cross-functional communication and coordination, and focusing on inter-firm alliances. Easingwood and Koustelos (2000) propose a practical four-step approach towards marketing of high technology products: (i) market preparation, (ii) targeting, (iii) positioning, and (iv) execution. The market preparation steps include approaches such as alliances, licensing, supply to OEMs, pre-launch awareness, market education, and special distribution arrangements. The targeting steps involve focusing marketing efforts on the innovators, pragmatists, conservatives, current customers, and competitors’ customers. The positioning steps include emphasis on exclusivity, low price, technological superiority, and consumer protection. Finally, the execution steps involve using opinion leaders, risk reduction strategies, image building, and tactical alliances. More recently, Hills and Sarin (2003) recognize that, although useful, the currently dominant marketing philosophies render themselves to be inadequate for addressing issues and problems specific to high technology industries and products. Their study proposes
'market driving' as opposed to market-driven or market-oriented as a new paradigm for marketing high technology products and innovations. Market driving is represented by “a firm’s ability to lead fundamental change in the evolution of industry conditions by influencing the value creation process at the product, market or industry levels” (Mohr and Shooshtari, 2003).

Though the above studies have focused on some specific elements and stand-alone issues in high technology marketing, a need exists for a study that provides a broad overview of the marketing-specific issues in high technology area and relates it to the lessons drawn from practice. Our paper aims to fulfill the above recognized gap in the literature.

HIGH TECHNOLOGY INDUSTRIES: DEFINITIONAL VIEWPOINTS AND CHARACTERISTICS

Moriarty and Kosnik (1989) and Shanklin and Ryans (1987) define high technology industries as characterized by a high degree of market, technological, and competitive uncertainty. Other researchers define high technology on the basis of inputs used. Output-based definitions used by some other researchers classify high technology products or industries based on the productive value-added output of firms. A related view of increasing returns and network externalities is discussed next. A more specific and detailed definition of high technology industry is based on the characteristics of an emerging techno-paradigm (Kodama, 1991). These viewpoints are discussed in the sections below.

Uncertainty View

Moriarty and Kosnik (1989) define high technology industries as characterized by a high degree of market, technological, and competitive volatility. It highlights the fact that it is the intersection of these three characteristics that typifies a high technology marketing environment. For example, some consumer goods industries might have high degrees of market uncertainty but they would not be classified as high technology if they do not operate under a high degree of technological uncertainty. Each of the three characteristics of the high technology environment is described in the sections below.

Market Uncertainty

It refers to the ambiguity about the type and extent of customer needs that can be satisfied by a particular technology (Moriarty and Kosnik, 1989). Figure 2 illustrates the sources of market uncertainty.

Figure 1: Characterizing the High Technology Marketing Environment

![Figure 1: Characterizing the High Technology Marketing Environment](image-url)

Market uncertainty arises from consumer’s fear, uncertainty, and doubt (popularly known as the FUD factor) concerning the needs/problems the new technology will address and how well will it meet those needs. Anxiety about these factors might result in customers delaying adoption of a new innovation. Also, customer needs may change rapidly and unpredictably in high technology environments. Next, customer anxiety may be perpetuated by a lack of clear standards and dominant design for innovations in a market. For example, ten years after they were introduced, only 20 per cent of the US households had purchased a colour TV. In many cases, the market for high technology innovations is slower to materialize (Moore, 1991).

**Technological Uncertainty**

This source of uncertainty is characterized by not knowing whether the technology or the company providing it can deliver on its promise to meet specific needs (Moriarty and Kosnik, 1989). Figure 3 shows that five factors give rise to technological uncertainty.

First, questions are raised regarding whether or not the new innovation will function as promised. The second relates to the time-line for availability of the new product which can always take longer than expected. Third, technological uncertainty may arise from concerns about the supplier and the service of the new technology. Further, there are concerns over the unanticipated side effects of a technology. For example, companies regularly debate whether the investments in information technology have really made their businesses more productive or whether the continued efforts to keep current with software upgrades and the use of computers for personal activities (like e-mail and surfing) have actually resulted in productivity decrement (Landauer, 1995). Finally, technological uncertainty exists because of the high degree of technological obsolescence.

**Competitive Volatility**

The third characteristic which underlies high technology markets is competitive volatility (Shanklin and Ryan, 1987). It refers to the changes in the competitive landscape such as identifying the competitors, their product offerings, the tools they use to compete, and so on. Porter’s (1979) five-forces framework could be a useful paradigm to understand this effect. Often, new technologies are commercialized by companies outside the threatened industry (Cooper and Schendel, 1976). These new players are viewed as disruptive and are frequently dismissed by incumbents. However, they end up ‘rewriting the rules of the game,’ and may change the face of the industry for all the players (Hamel, 1997).
Input-based View

Input-based view defines high technology products or industries on the basis of the physical or human capital inputs to the production process. Accordingly, the two major factors that drive input-based analyses are R&D expenditures and occupational profile statistics. Markusen, Hall and Glasmeier (1986) define all industries with an excess of job growth above the manufacturing average as high technology. Other studies have identified those industries with a higher than average proportion of engineers, technicians, computer scientists, life scientists, and mathematicians as high technology. Similarly, Diwan and Chakraborty (1991) examine two-digit SIC industrial sectors and use the level of scientific and engineering manpower, R&D expenditures, and relative level of skilled workers to determine which industries are high technologies. Other similar studies have defined high technology as an industrial sector which satisfies one of the two conditions: 1) percentage of the sector’s R&D expense in its value-added output is higher than 10, or 2) percentage of the sector’s scientists and engineers in total employment exceeds 10.

The advantage of the input-based approach is that, if proper data are available, then the high technology analysis is fairly straightforward. By adding gross R&D expenditure and summing the number of technical personnel, using appropriate weights, an ordering of technology-intensive industries can be derived in which the upper percentiles can be designated as high technology. However, as can be expected, a shortcoming of the input-based methods is the availability of reliable data.

Output-based View

Output-based definitions classify high technology products or industries based on the productive value-added output of firms. As compared to the input-based methodologies, the output-based methodologies have been less commonly used because of their less tangible criteria. Diwan and Chakraborty (1991) report studies which utilized interviews with scientists and technologists to determine which fields are advanced technology fields. Investigators then decided which product/processes involved significant amounts of leading-edge technologies. Other similar studies have analysed products at the five-digit SIC level and deemed them high technology based on experts’ and analysts’ judgments.

The relatively less measurable ‘degree of technological sophistication’ is a common feature of most output-based definitions of high technology.
tage of defining it by the degree of ‘sophistication,’ ‘complexity,’ or ‘advanced technology’ content is that the actual products of intense R&D, rather than money input, drive the essential meaning of high technology. Significant differences in the structure and aim of R&D activities and the type of technical personnel employed in R&D projects are, thus, factored out of this definition. However, there are some disadvantages to the output-based approaches and they explain, in part, the relatively more frequent use of the input-based definitions. First, output-based definitions rely on data that are neither highly accessible nor easily processed. Also, they can be highly subjective. To determine technological sophistication of products, one must gain intimate familiarity with their construction and function which is a demanding task as compared to summing up the R&D expenditures. This is compounded by the enormous amount of work required to obtain the ‘expert’ opinions.

**Increasing Returns and Network Externalities Views**

The earlier mentioned characteristics of uncertainty and volatility create a need for an industry-wide product standard to prevail. The firms whose technology is adopted as a standard in the market have a say in developing the attributes of various products and their complementary offerings. An important enabler of standard development is an increasing returns feedback loop. As the number of users employing a given technology increases, additional complementary technologies become available thus increasing the value of the overall system to existing and potential users. As this positive feedback cycle perpetuates, the size of the user base of the technology reinforces a product standard (Hills and Sarin, 2003). Related to the above aspect is the fact that most high technology products do not operate in isolation but, instead, function within a larger ecosystem of products and services. These externalities increase the rate of adaptation as well as current product obsolescence and speed up the new product development process. These, in turn, further increase the market and technological uncertainties.

**Techno-Paradigm**

A more specific and detailed definition of high technology industry, based on the techno-paradigm proposed by Kodama (1991), mentions that the technology industry is witnessing the emergence of certain characteristic trends in the organization and behaviour of firms. These trends, supported by substantial anecdotal and statistical data, emphasize intense research, predatory competition, and rapid innovation cycles that are commonly associated with high technology industry but are not included in the R&D-based definitions of high technology. These trends are summarized in Table 1.

The description of these trends implies that one should define high technology not by a simple ordering of research expenditures, occupational inputs or product complexity but by a combination of characteristic trends, including enormous R&D expenditure, predatory competition, substantial diversification, and innovation waves. Thus, high technology refers to the set of all industries which conform to a certain set of paradigmatic trends. While this definition still involves some subjectivity, it refines the working definition of high technology and discriminates among those industries which are typically considered science and technology-intensive. This definition is particularly useful for the researchers, policy-makers, and analysts who are less concerned with aggregate statistics and more concerned with the complexities of industrial structure and evolution.

In the rest of this article, we refer to the techno-paradigm and characterization of high technology products by Moriarty and Kosnik (1989) in terms of the high degree of market, technological, and competitive uncertainties. The discussion so far also implies that the

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Manufacturing inputs</td>
<td>High technology industries have developed enormous R&amp;D expenditure relative to other sectors. The ratio of R&amp;D expenditures relative to other capital investment may be greater than one in some cases</td>
</tr>
<tr>
<td>Business dynamics</td>
<td>Technological diversification has progressed to extreme levels in high technology industries; businesses must maintain such diversification for survival</td>
</tr>
<tr>
<td>Invisible competitors</td>
<td>High technology industrial innovations come in waves and firms must invest in several stages of technological trajectories simultaneously. Competitors are often companies in different industrial sectors</td>
</tr>
<tr>
<td>Demand articulation</td>
<td>The R&amp;D effort is targeted towards demand-side initiatives. Supply-side imperatives seldom drive the success of high technology firms</td>
</tr>
<tr>
<td>Technology fusion</td>
<td>Technological breakthroughs play a minor role in high technology industries; the paradigm for survival lies instead in combinations of existing technologies</td>
</tr>
</tbody>
</table>

evolution of high technology industry should also have a temporal dimension which makes it even more complex. For example, while a telephone might be considered a high technology product in the late 19th century, nano-technology or robotics might be considered as high-end technologies in today’s context. A temporal view of the evolution of high technology products is presented in Figure 4.

**COMPARISON OF HIGH TECHNOLOGY AND LOW TECHNOLOGY MARKETS**

High technology markets exploit and create change rather than consolidate and defend the existing conditions. Therefore, the interdependence between marketing and technology is of critical importance (Rosen, Schroeder and Purinton, 1998). Low technology companies may basically adjust their marketing strategies to reflect relatively stable technological conditions. High technology companies, however, must recognize that both technological and marketing conditions are rapidly changing (Nystrom, 1990). High technology markets are characterized by their dynamism and complexity which necessitate a changing target market over the life-cycle. The complexity of the product also impacts market acceptance in different ways in high technology markets (Davidow, 1986). As high technology products are more complicated, they require greater customer education and more product information.

High technology products result from innovations. Innovations can be thought of as falling onto a continuum from evolutionary to revolutionary (Christensen, 1997; Hill and Jones, 1998; Tidd, Bessant and Pavvit, 1997; Trott, 1998; Veryzer, 1998). While evolutionary innovation is critical to sustaining and enhancing shares of mainstream markets (Baden-Fuller and Pitt, 1996; Hill and Jones, 1998), revolutionary breakthroughs lie at the core of wealth creation (Schumpeter, 1975). In fact, by definition, revolutionary innovations serve as the basis of future technologies, products, services, and industries (Christensen, 1997; Hamel, 2000; Tushman and Anderson, 1986). The term ‘disruptive innovation’ has been used to describe innovation that is highly revolutionary or discontinuous in nature in which customers and consumers embrace new paradigms in favour of the old. Examples of disruptive innovations include the light-bulb industry’s disruption of the candle industry, the desktop computer industry’s disruption of the mainframe computers, the DVD industry disrupting the VHS industry and so on.

Any marketing strategy for a high technology product must take into consideration the following differentiating features of a high technology product:

- High technology product purchase is usually high involvement inducing because the perceived risk is greater.
- There is limited or no choice available for high technology products.
- The analysis for high technology is at product level (as compared to the low technology analysis at brand level).
- The focus of a high technology product is on problem solution whereas the focus of a low technology product is on brand attributes.
- The communication for a high technology product should have high information content.
- A high technology product may involve some amount of a push strategy for communication, promotion, and distribution.
- The existing distribution channels might not be sufficient for a high technology product. They evolve over a period of time. Further, high technology products have short channels to facilitate manufacturer control and ensure the quality and usage during the initial market launch.
- Demand pull brings in revenue for a low technology product whereas technology push brings in revenue for a high technology product until it reaches mass markets.
MARKETING IMPLICATIONS AND CHALLENGES IN HIGH TECHNOLOGY INDUSTRIES

In the earlier sections, we discussed some distinguishing characteristics of high technology industries such as high degrees of market and technological uncertainties, competitive volatility, high R&D expenditures, rapid obsolescence, and the presence of network externalities. These characteristics imply that marketing must be adapted and modified to effectively handle the resulting complex marketing environment (John, Weiss and Dutta, 1999). Further, since high technology firms are primarily engineering or product-oriented, they exhibit a culture in which engineering knowledge is valued more than marketing acumen. This necessitates the identification and discussion of specific challenges faced by marketers of high technology products.

Product Launch

The first issue that is relevant to product launch in high technology markets relates to the understanding of the difference between the manager’s and the customer’s perspectives. The manager’s perspective in a high technology industry is usually product-oriented. The adherents to this view believe that customers do not know what they want, are unable to articulate desires or are not knowledgeable about the products they seek. In the Indian context, as discussed in a later section, an energy-efficient furnace developed by The Energy Resources Institute (TERI) can be considered as a technological breakthrough in the grey cast iron melting furnaces. Although higher energy efficiency translates to a reasonable payback on investment, there are barriers such as prevailing practice, investment barrier, etc., which inhibit a faster rate of adoption of the new technology.

Several authors have suggested that high technology markets, unlike low technology markets, must focus on both demand-side and supply-side marketing (Shanklin and Ryans, 1987). Based upon the belief that supply can create its own demand, supply-side marketing appeals to new product developers who follow a product orientation. In practice, however, the supply-side so dominates the demand-side that the needs of the consumers are ignored in strategy development. As a result, product-oriented developers tend to be driven by their technology in determining the marketing mix.

The idea that the superior product will win out in the marketplace pervades much of the product development literature (Cooper and Kleinschmidt, 1987; Kleinschmidt and Cooper, 1991). However, the history of technology is full of examples that contradict this notion. Sony’s BetaMax, considered by many to be a better machine (Perry, 1988; Cusumano, Mylonadis and Rosenbloom, 1992), lost the market to the VHS format videocassette player largely due to not meeting the needs of consumers. Similarly, Philips’ Compact Disk Interactive (CD-I) entertainment system was billed as a major technological breakthrough for consumers as it combined the television and audio compact disc technology in an interactive system. However, sales of the CD-I system were disappointing largely due to the errors at the product launch in not focusing on the profiles of innovators and early adopters (Rosen, Schroeder and Purinton, 1998). Also, product readiness and availability is of prime importance in launching high technology products. A popular example is of Apple Computers which introduced Newton, a hand-held message pad computer promoted as a ‘personal digital assistant’ (Rosen, Schroeder and Purinton, 1998). Designed to compete with AT&T’s and Casio’s Zoomer, Apple did not have a completed prototype in May 1992 when Apple’s CEO introduced Newton due to competitive pressures. The personal digital assistant was a new product category in pocket size combining wireless electronic communication with file management and handwriting recognition capabilities. Although Apple claimed that its Newton could recognize handwriting, send faxes, and receive wireless messages, during the launch, it could not send wireless messages or receive faxes and was not particularly adept at handwriting recognition (Goldman, 1993). Thus, Newton was not a ‘complete product’ (Davidow, 1986) which contributed to its failure in the market.

Diffusion of Innovations and its Role in High Technology

Diffusion

In the context of marketing, diffusion is a special type of communication in which messages regarding innovation, or something new, are sent from the creator to the members of the population. The diffusion process consists of four key elements: an innovation, the social system on which the innovation impacts, the communication channels of that social system, and time (Rogers, 1983). The main focus of diffusion theory has been on the means by which information about an innovation is disseminated through the social system.
Rogers’ Normal Distribution Model

Rogers’ (1983) model of diffusion is based on the classical ‘bell-shaped’ curve which represents the frequency of consumers adopting a product over time. If the cumulative number of adopters is plotted against time, the result is an S-shaped (sigmoid) pattern. Rogers (1983) contends that the adoption curve is normally distributed because of a learning effect due to personal interactions within social systems. As the number of adopters in the system increases, the level of interpersonal influence on non-adopters also increases.

Rogers (1983) defines innovativeness as “the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system.” On this basis, as shown in Figure 5, Rogers proposes that the adopters of an innovation can be classified into five categories. These types differ in terms of their timing to adopt a new product and the sources of information they rely on to adopt new products.

Understanding the differences in the five adopter groups presents a way to successfully reach individuals at various stages of adoption as it provides a basis for the segmentation strategies (Rosen, Schroeder and Purinton, 1998; Robinson, Fornell and Sullivan, 1992). As the requirements for success change with the evolution of the market (Abell, 1978), this widely accepted adopter classification system should cause the innovative firm to research the characteristics of the innovators and early adopters and direct introductory marketing strategies specifically at them. This is particularly true in high technology markets where products more often present high-risk decisions (Davidow, 1986). McDonald, Corkindale and Sharp (2003) recently conducted a study which considers the efficacy of traditional psychographics and demographics versus behavioural variables on predictors of early adopters. Their results show that, in terms of demographics, the adopters were not significantly younger or wealthier than non-adopters but tended to be more highly educated than non-adopters. Early adopters relied less upon mass media than later adopters. The adopters had the following distinguishing characteristics: higher ownership of energy-saving products, greater likelihood of watching science-based TV programmes, greater likelihood of belonging to conservation groups, and higher propensity to own homes than non-adopters. In this study, the adopters were found to be not significantly different from the non-adopters on a scale of innovativeness. These results show that while there are some differences in the adopters and non-adopters categories, they are not exactly what intuition would suggest.

It is also important to understand that there is not a general innovativeness personality trait. Individuals may be early adopters for one product class and laggards for another. Consequently, it is extremely important for producers of high technology products to gather the necessary demographics, psychographics, and media

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**Figure 5: Different Categories of Adopters of an Innovation**

[Image of adoption curve with categories]

characteristics for each product introduction in order to ensure that they successfully reach the innovators and early adopters who are the key to a high technology product’s success. A critical aspect not explained by the Roger’s adoption model, and particularly relevant to the high technology products diffusion, is that there might be ‘cracks’ or ‘gaps’ in Rogers’ bell-shaped normal curve (Figure 6).

The innovator-early adopter gap exists when a new technology cannot be readily translated into a major new benefit. The key to winning the early adopter segment is to show that technology enables some strategic leap forward — something never before possible — which has intrinsic value to the firm. The early majority-late majority gap exists because the early majority is more willing to become technically competent to benefit from the technology than the late majority. Product must be made increasingly easier to adopt in order to reach the late majority. The innovators and early adopters represent the early phase of the evolution of markets whereas early majority and late majority with laggards represent the phase when the product has moved to the mainstream markets. For discontinuous innovations (innovations that force the user to change behaviour), there exists a wide gap termed ‘chasm’ between the early adopters and early majority which is also referred to as the ‘valley of death’ (Moore, 1991). Thus, the adoption process can be considered to consist of three distinct phases: an early market and a mainstream market separated by the chasm or the valley of death. Many high technology firms fail because they are unable to make the transition from early adopters to mainstream customers. At a time when a firm has just achieved great initial success from the initial market ‘early wins,’ it is difficult for the firm to undertake the immense effort and radical transformation necessary to serve the mainstream market.

**Segmentation Issues in High Technology Markets**

Research by Parasuraman and Colby (2001) shows that technology readiness (TR) is a key factor in the adoption of innovative products and services. TR refers to the propensity to adopt and embrace technology in home life or work. It reflects a set of beliefs about technology. Although explained primarily in the context of high technology consumer products, the concepts of TR can be highly predictive of the speed of technology adoption and level of usage of technology in all kinds of high technology markets.

TR is multi-faceted with some factors being contributors and others being inhibitors. The contributors include:

- **Optimism**: The degree to which one believes in the inherent benefits of cutting-edge technology such as offering convenience, time flexibility, mobility, and stimulation.

- **Innovativeness**: The tendency to experiment with new technology including gathering information and influencing others.

The inhibitors include:

- **Discomfort**: A perceived lack of control over technology including a desire for assistance and a preference for simplicity.

- **Insecurity**: Concern about the safety, security, and privacy of technology as well as a need for assurance that it is working properly.

Parasuraman and Colby (2001) propose that the

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*Figure 6: Modified Bell-shaped Curve of Adoption of Innovation for High Technology Products*

![Modified Bell-shaped Curve](image-url)

*Source: Moore (1991).*
four dimensions are relatively independent. In other words, one can simultaneously have both positive and negative feelings about technology.

TRI is an index for measuring technology readiness of a potential adopter. It uses a series of belief statements in a survey to quantify an individual’s overall level of technology receptiveness. The research on techno-readiness shows that people react differently when encountering cutting-edge technology and can be categorized into five distinct segments. Each ‘techno-type’ has different beliefs about technology based on the four TR dimensions of optimism, innovativeness, discomfort, and insecurity. The segments vary in demographic and psychographic terms and in the speed and intensity in which they adopt technology. In the order of overall TRI, from highest to lowest, the segments are labelled as: (i) Explorers, (ii) Pioneers, (iii) Skeptics, (iv) Paranoids, and (v) Laggards. The similarities between the techno-type classification and the one depicted by Rogers’ (1983) model are readily noticeable. Each technology segment presents a different set of obstacles and opportunities for a new product and each segment requires a different marketing strategy to ensure the long-term success of the product. For example, earlier stages of marketing require an emphasis on technology evangelism and advanced functionality (directed at Explorers) while later stage strategies require an emphasis on useability, technical support, reassurance, and clear communication of benefits.

Market Research Issues in High Technology Markets

Certain marketing research concepts such as sampling gain different connotation or are rendered irrelevant when applied to high technology markets. Also, specific research tools or methodologies used in high technology markets such as lead users or outcome-based methods are different from those used in standard marketing research (Leonard-Barton, Wilson and Doyle, 1993).

Expert Opinion and Niche Applications: Sampling vs Census

An important issue in research design in market research studies is regarding what sample size to choose. One option is to contact each relevant respondent and get his/her views on the marketing research problem. Such a process is called census in contrast with sampling. It is obvious that carrying a census may be unrealistic or impractical if the population is large as is the case for most of the consumer products. On the other hand, often, the high technology or industrial markets involve a small number of relevant respondents. For example, if a market research agency is interested in questions regarding the robotics application in niche application areas such as oceanography, space or mining, then there are a very small number of organizations present in any country. This aspect, coupled with limited penetration of robotic applications in the world, makes a near-census approach quite relevant using the researchers’ judgment and convenience. Further, the small population of experts in case of industrial robots in a country makes a census feasible as well as desirable. Another reason for preferring to use census is the nature of variance. The variance is likely to be larger because of different potential applications of high technology products such as robots. For example, industries having the potential application of robots in an automobile industry will vary greatly from those in pharmaceuticals. The costs of the sampling errors in the presence of such variance can be quite large for a study of this nature.

Lead User Study

Lead users are the users whose present strong needs will become general in the market in the future and who are positioned to benefit significantly by obtaining a solution to those needs. Since lead users are familiar with conditions which lie in the future for most others, they can serve as a need-forecasting laboratory for marketing research. In rapidly changing high technology industries, the lead users who have real-life experience with novel product or processes are essential for accurate marketing research. In the case study on TERI, to be presented later, the lead users are those cupola owners who have been attempting refitment and refinement procedures to the basic cupola to improve its energy efficiency.

Outcome-based Methodologies

According to Ulwick (2002), many companies ask customers what they would like to see in new products or services. Customers often describe the products that they want typically in a focus group or by means of a survey questionnaire. However, when many of these innovations are introduced in the marketplace, the response is a resounding flop. Ulwick (2002) finds the process of asking the questions in terms of tangible attributes faulty and instead proposes a new pragmatic
methodology called the outcome-based methodology which has been found to give successful results in practice. Following this methodology, the researcher focuses not on what features the user-respondent, say, a cardiologist, would like to see in an angioplasty balloon but rather on the results he/she wanted to achieve in doing his/her jobs — before, during, and after the surgery. Ulwick (2002) further proposes an opportunity algorithm which facilitates computations of a market-opportunity score to organize the outcomes.

DIFFUSION OF AN INDUSTRIAL INNOVATION: A CASE-STUDY OF AN ENERGY-EFFICIENT FURNACE

Background of the Foundry Sector in India and the Efforts by TERI

There are about 5,000 grey iron foundry units in India most of which are in the small-scale sector. Foundries melt pig iron and scrap to cast them into useful shapes. Some common items produced by foundry units are manhole covers, sanitary pipes for buildings, water pipes for municipalities, hand-pumps and water pump-sets, electric motor bodies, automotive parts, and industrial items.

A majority of the small-scale foundry units employ cupola for melting. Cupola is a vertical-shaft furnace using coke as fuel. A blower supplies air for combustion of the coke into the furnace. Correct quantity and pressure of the combustion air and its distribution are crucial to ensure efficient combustion. Most of the operating cupolas have been designed and fabricated by local fabricators (or mistries) having little formal technical knowledge. This results in inefficient combustion and higher energy consumption.

In order to showcase an energy-efficient cupola design to small-scale foundry units, TERI set up a demonstration plant consisting of an energy-efficient cupola design called the divided blast cupola (DBC) at a foundry unit in Howrah. After successful demonstration, the challenge was to replicate the technology among the other foundry units. The market research and promotion activities conducted to disseminate the technology, the barriers encountered, and alternative marketing strategies being adopted are summarized below.

Market Size Determination

A foundry unit would replace its existing cupola by an energy-efficient cupola only if the payback on investment, through coke saving in its operation, was found to be attractive. Hence, an analysis to estimate the size of foundry for which the payback on investment will be attractive was made.

For a 100-tonnes/month foundry, the annual charge, coke consumption bill varied from Rs. 1.94 million to Rs. 2.30 million depending on the quality of coke. The supporting calculations are given in Exhibit 1.

Assuming coke saving of 20 per cent by adoption of DBC, there is a reduction in the energy bill of Rs. 39 million to Rs. 0.46 million per year. The capital cost of DBC is Rs. 0.8 million which is inclusive of blower, charging system, platforms, and civil work. These figures suggest a payback period of approximately two years. Following similar calculations, the payback period for foundries melting 200 tonnes/month or more would work out to be less than a year. Hence, adoption of DBC is particularly attractive for foundry units that melt more than 200 tonnes/month.

The foundry units in India melt a gross tonnage of about 3.9 million tonnes per annum. With 5,000 foundries in operation, the average melting per foundry would be 780 tonnes per annum or 65 tonnes per month. Applying the 80:20 rule, it was estimated that the average melting of the largest 20 per cent of the foundry units (that is, 1,000 units) is about 3,110 tonnes per annum or 260 tonnes per month. These units can be considered reasonable potential adopters of this technology. Thus, the number of foundry units in India which are potential adopters of this technology is approximately 1,000.

Target Segment

Based on the classification by diffusion theory of adopters of an innovation in five broad categories — innovators, early adopters, early majority, late majority, and laggards — it was found that the innovators were those units that were willing to take calculated investment risks, are proactive, and generally more progressive. It was deduced that the initial adopters of the technology will be the innovators and hence it was

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1Coke savings achieved in the demonstration plant was 32 per cent and the replication unit was 40 per cent. A conservative estimate of 20 per cent saving is taken here. This figure can be considered as the minimum savings possible for cupula in Indian foundries.
decided to target this segment first. A longer-term strategy for replication was to establish a rapport with the initial adopters of the technology and develop them as industry mentors. Successful diffusion of the technology would then depend upon managing and using the industry mentors for replication at the cluster or regional level. A study of the lead users, that is, those cupola owners who have been attempting refitment and refinement procedures to the basic cupola to improve energy efficiency, would also be helpful for future dissemination of the technology.

**Estimating the Rate of Diffusion**

Research on diffusion of technological innovation indicates that the rate of diffusion with time usually follows the S-shaped curve. The inflection or ‘take-off’ occurs after 10-25 per cent of the market has adopted the technology since after the adoption by that proportion, interpersonal networks become activated. The concept of increasing returns and network externalities is also relevant here. As the number of users of energy-efficient DBC technology increases, additional complementary technologies are likely to become available, thus increasing the value of the overall system to existing and potential users. When this positive feedback cycle perpetuates, the size of the user base of the technology would establish DBC as a normative standard. This would give rise to a larger ecosystem of products and services. Such externalities are likely to increase the rate of current technology obsolescence and speed up the new technology diffusion process.

Keeping in view the skepticism of the target group towards adoption of a new technology, 12 replications were targeted in the first three years. The above target does not include the number of replications by imitation since it is difficult to get information about such imitations. After the initial period, the gradual lowering of the capital cost and establishment of delivery mechanism at regional levels is expected to accelerate the rate of diffusion to 6-8 replications per year. Therefore, it is estimated that this ‘critical mass’ of 10 per cent adoption, or 100 replications, will be reached around 2015-16 for this technology as shown in Figure 7.²

**Market Promotion**

One of the bottlenecks to disseminate the technology was the lack of information with regard to size of the foundry units, type of product, energy performance of melting furnace, and local technology suppliers. Since most of the foundry units are geographically clustered, it was decided to undertake market evaluation of the most promising foundry clusters to collate market in-

²The graph is only a schematic depiction. The actual shape of the curve will depend on the values of alpha (coefficient of innovation) and beta (coefficient of imitation). In this case, beta is likely to be higher than usual because of the imitation effects in clusters of foundries and, therefore, a steeper upward slope may occur before 2015-16.

**Figure 7: Diffusion Curve of DBC in Indian Foundry Units**
formation and prepare target lists. Cluster inventorization of the following foundry clusters was undertaken through regional organization in 2001-02: Coimbatore, Belgaum, Kolhapur, Rajkot, and Punjab (Jallandar and Batala). Dissemination workshops at cluster level were also held to spread awareness about the technology. After the questionnaire surveys, personalized direct mailers were sent to the target audience along with a printed information brochure. One-to-one meetings with foundry units showing interest were held in each of the selected clusters. The specific details of various promotion activities planned by TERI are provided in Exhibit 2.

**Barriers to Adoption**

In spite of these market promotion activities, the initial response from the industry to adopt the technology can be termed as ‘lukewarm.’ Only three foundry units, two from Coimbatore and one from Rajkot, signed up immediately following the cluster level market promotion activities. Some factors that prevented greater number of foundry units from adopting the technology were felt to be the following:

- **Barrier due to prevailing practice:** Conventional melting furnace was well-entrenched in the units. Since an existing furnace has a life of about ten years, most entrepreneurs were reluctant to discontinue the usage of their old furnace and build a new one especially since it involved higher cost and time commitments.
- **Limited in-house technological capability:** Most foundry units have limited technological capability to evaluate and absorb new technologies and hence are apprehensive of managing change to new operating practices.
- **Investment barrier:** The new technology required higher upfront investment compared to conventional technology. Small-scale units are very cost-sensitive and typically look for first-cost minimization options rather than life-cycle costs.

**Discussion**

In the last six years, the DBC design of TERI has been adopted by about ten foundry units spread all over India. It can be argued that the rate of replication would have been higher if dedicated salespersons were appointed in different foundry clusters for business development. However, engagement of a reputed foundry consultant at Howrah after the technology was demonstrated did not directly convert to orders. Hence, it can be deduced that deployment of a dedicated sales team might not have accelerated the rate of uptake of the technology greatly probably because of the barriers mentioned earlier.

TERI has also adopted a different approach to marketing the technology. This approach is based on the philosophy of vendor development which presumes that an industrial unit, particularly in the small-scale, would invest in a new technology if the customers demanded better quality and/or lower cost. As long as the expectations of their customers are met, such units would be reluctant to bring about technological changes involving large capital. Therefore, if the bulk buyers of castings, such as automobile companies, can be educated about the benefits of the new technology, they could, in turn, influence their vendors. TERI is in the process of preparing a list of large buyers and exporters of castings. Subsequently, it proposes to organize workshops and meetings with some of these bulk buyers for educating them about the benefits of the new technology.

Although Parasuraman and Colby’s (2001) technoreadiness construct has generally been explained for high technology consumer products, its relevance can also be established in the context of the situation faced by TERI. For example, the contributing factors to the adoption of DBC technology could be optimism (the degree to which a foundry unit owner believes in the inherent benefits of the DBC technology such as offering increased energy efficiency, adherence to environmental norms, cost savings, etc.) and innovativeness (the tendency of a foundry unit owner to experiment with the new technology including gathering information and influencing others). Similarly, the inhibiting factors would include discomfort (perception of lack of control over new technology, desire for assistance and training, preference for simplicity) and insecurity (concerns about the efficacy, safety, security, and privacy of technology). A survey of foundry unit owners collecting data on the above factors would provide alternative ways to segment consumers in this high technology market.

Finally, for future dissemination of the DBC technology, TERI must consider sponsoring a formal mar-

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3 The demonstration plant at Howrah was commissioned in September 1998.
4 The figures do not include diffusion of the technology by ‘imitation’ which is quite common in small-scale sector since TERI does not have actual data about such units. However, it is estimated that at least an equal number of units might have imitated or copied the DBC design and their number is expected to grow steeply.
Marketing research study to assess the marketing potential of the new technology in India. Following Malhotra’s (2002) framework for marketing research problems, the management decision problem for such a study could be defined as: Should we promote the DBC technology further or not? Its associated marketing research problem(s) could be to assess the marketing potential of the DBC technology in India, and, if the potential is found attractive, to provide marketing strategy formulation for the dissemination of the technology. A representative eight-step procedure for conducting such a study is provided as follows:

- management decision problem
- marketing research problem
- research design
- sampling design
- contact methodology
- field work and data collection
- data preparation and analysis
- report generation.

CONCLUSION AND IMPLICATIONS

Though some papers in the literature have addressed specific issues in the area of marketing of high technology products, to the best of our knowledge, no study exists which integrates various issues in high technology marketing. The aim of this paper, as well as its major contribution, is to fill the above-mentioned gap in the literature. Towards this end, we first discuss various definitional viewpoints and characterizations of high-technology industries. The uncertainty, increasing returns, and network externalities views primarily provide definitions and conceptualization of high-technology industries and do not focus on measurement issues. The input-and output-based views take a more measurement-oriented approach by focusing on either the measurable characteristics such as R&D expenditures and occupational statistics or subjective measures such as experts’ and analysts’ judgments. These approaches provide a better classification in terms of the ordering of various industries on the high technology scale but suffer from the shortcomings such as availability of reliable data. The techno-paradigm approach by Kodama (1991) provides a more specific and detailed definition of high technology industries in terms of certain trends such as manufacturing inputs, business dynamics, competition, demand articulation, and fusion of technology.

Based on the extant literature, we next provide a comparison of high technology and low technology markets by discussing their distinguishing characteristics. We then discuss some important marketing-related challenges that high technology industries routinely face. A salient point that emerges from this discussion is that the launch of a new product should be handled very carefully. The failure to do so results in many product failures as has been discussed in the literature (Rosen, Schroeder and Purinton, 1998). The understanding of the concepts of diffusion of innovation is quite useful at the planning stage of the product launch. Diffusion theory underscores the importance of innovators and early adopters in the success of a high technology product. The concepts of ‘cracks’ or ‘chasm’ in Rogers’ (1983) original bell-shaped adoption curve provide a new dimension in the context of high technology products.

The case study of TERI presented in the paper discusses unique challenges faced by the organization in marketing an energy-efficient technology. It provides some important points relevant for technology marketing in the small and medium enterprises sector. First, there is a need to involve user groups and market actors so that the elaborated solutions are better accepted by the target groups leading to accelerated dissemination of the technology results. Second, the technology solution needs to be customized to suit the requirements of the end-users. It is also important to provide on-the-job training and skill upgradation of the workforce to facilitate better absorption of the new technology. For a larger-scale replication of the new technology, there is a need to look at newer approaches to marketing including influencing end-users of castings, techno-readiness-based segmentation, and formal marketing research.

Exhibit 1: Calculations of Energy Bill

**Assumption:** The coke consumption in conventional cupola varies between 12 to 18 per cent depending upon the coke quality. Ash content of the coke is a measure of coke quality. The cost of coke varies in the range of Rs. 9,000 — Rs. 16,000 per tonne (the lower the ash content, the higher the price).

**Energy bill for a foundry unit melting 1,200 tonnes/year using low ash (better quality) coke is** 

\[(1,200 \times 0.12 \times 16,000) = Rs. 2.30 \text{ million/year}.\]

**Energy bill for a foundry unit melting 1,200 tonnes/year using high ash coke (poor quality) coke is** 

\[(1,200 \times 0.18 \times 9,000) = Rs. 1.94 \text{ million/year}.\]
Exhibit 2: Promotional Activities Planned by TERI for Acceleration of Diffusion

The activities or tasks that need to be undertaken for a) above-the-line marketing, b) below-the-line marketing, c) promotional material, and d) strategic partnerships are as follows:

**Above-the-line Marketing**

This approach refers to the communications aimed at reaching out to target audience. The activities that need to be undertaken are as follows:

- Organizing regional level workshops/seminars.
- Advertising in industry journals and newsletters.
- Participating in annual foundry congresses organized by industry associations.
- Launching of a website named ForeCASTING to provide details of the technologies being offered apart from general information pertaining to technology, regulations, financing, marketing, etc.

**Below-the-line marketing**

This approach refers to the communications targeted at individual potential adopters. Some activities of this approach are listed below:

- **Direct mailing**: An information dissemination brochure could be mailed directly to foundry units. Available foundry industry databases (e.g., IIF, IFA, Rajkot engineering Association, CODISSA, etc.) would be consolidated for this purpose.
- **Telemarketing**: Individual foundry units could directly be approached through telephone especially as a follow-up after mailing of a letter and brochure.
- **Direct marketing**: Cluster surveys are an important direct marketing tool to reach out to individual foundry units and prepare an industry database. A beginning has already been made in five foundry clusters — Coimbatore, Belgaum, Kolhapur, Rajkot, and Batala/Jalandhar. Based on the learning from this exercise, the approach would be extended to other clusters as well in the future.
- **Individual plan**: After the surveys, individual meetings with the progressive foundry units would also be held.
- **Referral plan**: A system in which current users of the technology provide referrals for potential users of the technology would be devised.

**Promotional Material Production**

Preparation of the following promotional material would be initiated:

- **Video film**: A video-film would help to show the demonstration and replication plants in operation to the viewers. The film would be used during the workshops and seminars organized and also at the foundry congress stall.
- **Information flyers and display posters**: For publicity during foundry congress and other events, one-page flyers and display posters would be used.

**Display model**: Displaying a model of the demonstration plant would be helpful in attracting attention during the seminars and foundry congresses.

**Strategic Partnerships**

Some areas for partnerships/tie-ups would help in providing strategic inputs in specific areas, enhance branding, and ensure superior service to users.

**Building relationships with initial adopters**: Since potential foundry units are likely to take feedback from those who have already replicated the technology, building relationships with the initial adopters is vital. The initial adopters could be treated as ‘partners’ if they are developed as ‘industry mentors.’ A possible way of enhancing this relationship is to invite them to project activities and provide them information sheets/flyers.

**Partnership for local delivery**: The need to develop partnerships with local organizations/consultants which would be local nodes of TERI for assisting in project implementation activities is felt for sustaining the initiative in the longer term. Technical consulting organizations, engineering firms, foundry equipment suppliers or individual consultants could be possible local partners for this kind of activity. The local partner should see a longer-term commercial business interest even beyond the present intervention. Hence, it is suggested to make efforts to identify suitable regional partners and involve them in the replication activities.

**Strategic inputs in marketing**: There is a strong need identified by TERI for external support to planning and strategizing the marketing activities. Some areas where specific support would be useful is on fine-tuning and implementing the marketing activities and development of promotional materials like flyers and video films. However, since the marketing of technological innovations like these is different from product marketing, the relevant persons should be identified from management institutions (e.g., IITs, IIMs) who have backgrounds in both technology and management.

**Financing partnerships**: Since most of the initial adopters of the technology are likely to be progressive foundry units, they would have access to and credibility with commercial banks or lending institutions. However, for more widespread replication, it would help to develop a financing mechanism for units which do not have strong balance sheets and are not in a position to offer collateral against the loans. Since loans to such units are ‘risky’ from the point of view of lenders, innovative methods of financing need to be worked out.

**REFERENCES**


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I have never come across anything in nature that is superfluous and does not fulfill a function. There seems to be no redundancy or unemployment in these natural worlds. Be it rock or plant, bird or tree, or even the bacteria within the soil, everything occupies a vital place in the dance of life.

— Michael Lindfield