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Technology Intelligence as a Source of Competitive Advantage

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ABSTRACT

New Product development (NPD) is the most typical innovation activity of companies and will determine the profitability and growth potential of the company's future. However, the strategic decisions in NPD have an extremely complex and fuzzy nature, due to today's rapidly changing and highly uncertain business environment. The aim of this research is to improve the accuracy of decision-making support with competitive advantage in technological innovation, under a situation of increased competition. In this research on the basis of Business Intelligence and Competitive Intelligence theoretical studies, the effective method of collection, analysis and evaluation of technology information is proposed, and the importance of technical information source selection while exploring information demanded in NPD is revealed. In addition, the effective usage of technical information sources was examined. Finally, this paper presents the technology analysis observed from the Technology Intelligence-based decision support approach for NPD in product life cycle stages with competitive advantage.

Keywords: Technological Innovation, New Product development, Technology Intelligence, Product Life Cycle, Com-petitive advantage

INTRODUCTION

The corporate environment is undergoing fast changes due to globalisation and intense market rivalry. The management of design choices in the creation of new products or technologies is intricate and conducted amidst uncertainty, stemming from heightened product complexity, changing client demands, and abbreviated product life cycles. An 'innovation' refers to the creation of a novel concept and its subsequent implementation. Technological innovation may be categorised in many manners: product vs process, radical (fundamental) versus incremental (improvement), and disruptive versus sustaining (sequential and/or complementary). Effectively managing innovation in comparison to rivals is a primary priority for businesses aiming to survive and prosper in the contemporary market. NPD (New Product Development) refers to the whole process of introducing a new product to the market.

The method may be categorised into two primary phases: the Fuzzy Front End (FFE) and the execution of product development. The FFE encompasses actions that precede the more formalised and organised NPD process [1]. Despite the continuity between the FFE and NPD, the actions inside the FFE are often chaotic, unexpected, and unstructured. Many organisations delineate the ideas inside the Front-End of Innovation (FFE) and use the conventional "Stage Gate" method in New Product Development (NPD). Koen et al. [3] identify five distinct front-end elements: Opportunity Identification, Opportunity Analysis, Idea Genesis, Idea Selection, and Concept and Technology Development. They include all actions from the exploration of fresh prospects to the inception of an idea and the formulation of a definitive notion.

Myers and Marquis [4] develop models of technological innovation that meet needs and technology. The new product development process starts with the creation of ideas. For each successful new product, several product concepts are generated and then rejected. Consequently, organisations often produce a broad array of ideas from which successful new products arise. The essential aspect is their ability to produce novel concepts and transform these ideas into marketable products. For example, concerning data on technology and client requirements, information is gathered and organised by priority. Consequently, an innovative technology may arise to fulfil client requirements. To ensure the success of new product development and technical innovation, companies must constantly monitor the technological, market, and competitive landscapes to gather information on environmental changes and market reactions. Sources for insights into the market and the potential success of new goods include senior management, sales agents, customers, distributors, and rivals of the firm, among others. Understanding the idea and method of information and intelligence management is crucial prior to the collection, analysis, and evaluation of information. Intelligence is described as the ability to acquire and evaluate information that aids in decision-making.

Intelligent decision support depends on methodologies from several fields, including artificial intelligence and database management systems. Nevertheless, the majority of the current literature overlooks the specific function of technological intelligence (TI) in connection with innovation. Despite the extensive literature on various technology intelligence methodologies, there is a deficiency of study about the determinants that influence the selection of suitable technology intelligence approaches. The gathering, analysis, and utilisation of competition information throughout the NPD procedures have not been thoroughly executed due to insufficient practical application expertise.

This study emphasises the significant contributions of effectively using various tools within the TI system to the commercialisation of new technologies, achieved via the introduction of improved goods and/or services. For the purpose of clarity, it emphasises that technical innovation (TI) is a crucial factor in corporate rivalry, significantly influencing technological advancement. It delineates technical intelligence for decision-making help in new product development and technological innovation. It also elaborates on the function of TI at each step of the Product Life Cycle (PLC). This project aims to investigate technical information sources to meet information requirements for new product development decision-making, grounded on theoretical studies of technology intelligence, and to provide preliminary insights into a decision support framework that confers competitive advantage.

The remainder of this work is structured as follows. Section 2 elaborates on the literature review pertaining to research in information management and intelligence management. Section 3 provides an examination of technological information sources and elucidates how intelligence is derived from this information to enhance NPD decision-making. Section 4 provides an in-depth analysis of the successful use of Technology Intelligence to facilitate New Product Development (NPD). Section 5 provided a study of technology in New Product Development as perceived through the lens of a Technology Intelligence-based decision support framework. A conclusion was formulated based on this study, emphasising topics for further investigation.

LITERATURE REVIEW

This section aims to succinctly examine literature pertaining to intelligence management and analytical methodologies. In studying decision-making, we must first examine the management information system and data processing that underpin corporate decision-making. The notion of facilitating business decision-making with extensive internal and external data originated during the mainframe era. During the 1970s, Management Information Systems (MIS) and in the 1980s, Decision Support Systems (DSS) supplied the necessary information to facilitate decision-making. In the 1990s, Data Warehousing (DWH), Online Analytical Processing (OLAP), Data Mining (DM), and several other data processing methodologies were created. Nonetheless, data mining and OLAP still need skills or technical personnel to gather and handle data. Since the beginning of 2000, advancements in information technology have rendered information more visible and efficient. Business Intelligence (BI) serves as the company's management information system, facilitating data storage, collecting, and analysis to guide business decisions. corporate Intelligence (BI) is used to examine internal data and corporate operations, while Competitive Intelligence (CI) collects and analyses information specifically about rivals. Industry data, product details, and technical specifications are essential competitive information for informed management decisions.

The successful launch of a new product is essential for a corporation to sustain its competitive advantage. Nonetheless, several challenges and ambiguities accompany the new product development process. Companies allocate resources to research and development, cognisant that a small fraction of viable product concepts can attain market success. The utilisation of CI to enhance the recognition and acquisition of business prospects, to provide effective assistance for strategic choices, and to establish a new competitive edge are pivotal challenges confronting contemporary firms.

Competitive intelligence empowers senior executives in organisations of all sizes to make educated choices on marketing, research and development, investment strategies, and long-term company planning. Effective competitive intelligence is an ongoing process that includes the legal and ethical acquisition of information, analysis, and distribution of actionable insights to decision-makers. The implementation of CI capability necessitates the integration of a CI unit into the company's organisational framework.

Technical Intelligence (TI) or Competitive Technical Intelligence (CTI), as a component of Competitive Intelligence (CI), is an endeavour that allows organisations to discern technology possibilities and dangers that may impact their future development and viability. Savioz[8] describes Competitive Technology Intelligence (CTI) as the collection, analysis, and evaluation of information pertaining to rivals' products or technologies, alongside the prompt dissemination of technical data and trends relevant to information technology management to facilitate corporate decision-making. Savioz selected a medium-sized firm in the medical technology sector in Switzerland and identified a set of guiding principles for the establishment of technological innovation in SMEs (small and medium-sized

companies). Lichtenthaler[9]–[12] posits that technological innovation is contingent upon an organization's decision-making style and culture. He selected 25 multinational corporations as subjects for his research and examined the flow and analytical processes of information regarding technological trends within these organisations, the decision-making processes of managers concerning these trends, and the various roles of the technology intelligence analysis team in these processes. Lichtenthaler et al. [13] established the notion of technology intelligence, which involves analysing a certain environment with a particular focus on detecting technical licensing prospects.

The extant literature indicates that the implementation process, from a CI/TI perspective, encompasses the gathering of technological information, monitoring, analysis, forecasting, prediction, and early warning to delineate the process. This study aims to analyse the use of intelligence in strategic decision-making processes within New Product Development (NPD). Subsequently, the companies may use TI to gather, examine, and assess information on the technology required to bolster competitiveness.

Intelligence from Information for NPD decision support

The general technology information needed for NPD include new technology trends, technical standards, competing technologies and alternative technologies etc. In this section we will discuss how intelligence is gathered from information by and analysed for NPD decision support.

Technology Information Sources

Regarding information sources research, there are many researches on human relationships [14],[15]. Finding information in social networking services (SNS) have received extensive attention recently [16]. Toni Wilson [17],[18] discusses the sources of economic intelligence and competitive intelligence. However, the research for the sources of information on technical intelligence, and how to obtain technology information from a reliable source is still not covered.

When Brenner [19] talks about technology intelligence and technology scouting, the author expresses the relationship between technical information sources and signal strength of the relationship along the new product introduction time line from development until going to the market. The first signals often appear in scientific and technical discussions; following signals include scientific publications, research cooperation, R&D alliances, joint ventures or partnerships which are shown. These signals might be weak, but gathering, assessing, and communicating this information are crucial objectives to uncover and anticipate new technology trends or commercial developments. Later, patents will begin to be issued, which are usually applied three to four years prior to development. Next, process development efforts on the new technology might be rumoured. Finally, near the end of the development cycle, the strongest signals occur, perhaps involving a product release or competitive product sales. Brenner re-emphasized the importance of gathering the information signal in the early stage in the case studies on aerospace products [20].

It can be possible to gather technology information in industry or competitors, to provide technological innovation strategy support by detailed technical analysis, based on scientific literature and research and development trends analysis, as well as patent information which is the core of the information. However, in order to get the product to the market as soon as possible, enterprises sometimes start product development before patent applications. Therefore, during product planning, it becomes essential to understand early weak signal dynamic information such as scientific literature, research and development information etc.

Information Gathering

The government proactively offers information services to improve the worldwide competitiveness of industry. In Japan, the central government determines science policy and industrial development strategies, while independent administrative organisations, such as the Japan Science and Technology Agency (JST) and the New Energy and Industrial Technology Development Organisation (NEDO), formulate detailed technical roadmaps and implementation plans. They have the long-term obligation of following, monitoring, gathering, and assessing technological developments to stimulate the expansion of essential sectors. The reports from these government entities provide significant information about several technological advances. Insights may be derived from government publications, national policies, activities, and scientific and technology advancements.

Scientific literature, research papers, and other academic texts serve as a significant source of technical knowledge. Their contents are highly technical, of superior quality, and they embody the academic standards of professional fields, research advancements, and trends. By examining scientific literature and journal articles, we may ascertain the industry's foundational research and outcomes, therefore comprehending the trajectory of future technological advancements.

The information inside current patent filings is crucial for the creation, evaluation, and development of an invention. This information may provide valuable insight into the novelty of an idea and the decision to further its development.

Moreover, thorough research of patent information might provide insights into the strategies of prospective rivals and technological trends. The corporation will generally promote staff to file patents to safeguard its intellectual property rights. Consequently, the examination of patent information may assist organisations in comprehending the landscape of patent applications and technological advancements. However, for high-tech items, to avert the disclosure of product development initiatives and to ensure the new product reaches the market before to rivals, patent applications are sometimes postponed or forsaken. Consequently, it has become more essential to forecast the trends in a competitor's product development by analysing scientific literature and publications to uncover the foundational research strengths of the industry and its rivals.

Definite connections may be identified independently of human experience and intuition using approaches such as data mining and artificial intelligence. A comprehensive overview from embryonic research to product development and commercialisation may be derived using patent literature and meta-analysis of scientific publications. The aforementioned sources of information on the technical aspects of signal intensity may be consolidated and are shown in Figure 1.

The personnel of the firm across numerous functional divisions own significant technical knowledge, including technical reports, standards, product surveys, documentation, test results, manuals, publications, and meeting records. Numerous Japanese corporations prioritise internal company information. The Japanese Ministry of Science and Technology Policy Research's innovation survey report from September 2010 indicates that the primary sources of technical knowledge are internal groups, suppliers, and consumers. The proportion of scientific literature and patent information regarded as significant sources of knowledge remains rather limited. Acquiring information from an organization's internal group is a notable trait of Japanese corporations, since a substantial amount of external information has been assimilated into the organization's internal data.

Timely and precise information gathering and analysis may enhance comprehension of technological developments and trends, while also offering early warnings to prevent potential threats to a company's operations. With the advancement of information technology and the practical application of information visualisation, intelligent retrieval, intelligent collecting, data and text mining, information extraction, and information filtering, TI has gained widespread use. This information must be derived from credible sources. Determining the legitimacy of technological information is a key problem, since such knowledge necessitates skilled, dependable, and valuable sources.

Information Analysis

For decision-making and subsequent actions, it is important that collected data be converted into intelligence. This is accomplished through analysis [21]. Fieisher and Bensoussan [22] provide 24 commonly applied methods for decision makers. They cover classic techniques, such as McKinsey 7S and industry analysis, as well as emerging techniques from multiple disciplines: economics, corporate finance, sociology, anthropology, and the intelligence of futurist communities. For each, they present clear descriptions, background context, strategic rationales, strengths, weaknesses, step-by-step instructions, and references.

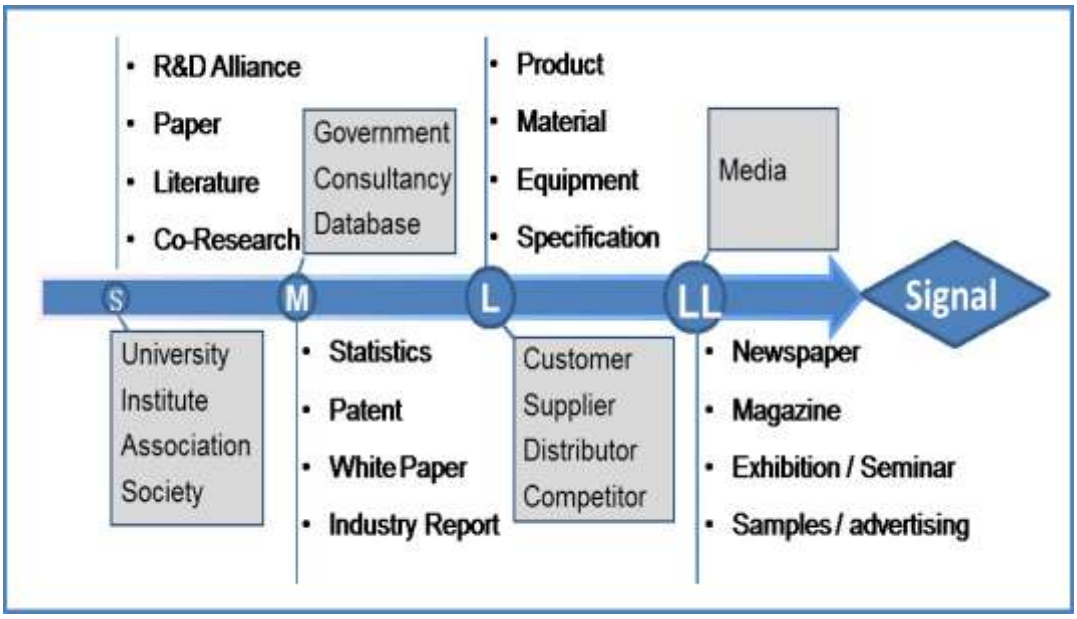

Fig. 1 Technology Information Sources and Signals Intensity

Figure 2 shows the frequency of the use of analysis methods feedback from survey results of 27 professionals in the Japanese Society of Competitive Intelligence (JSCI). Most questions used the 7-point Likert scale (1 = "" stronglydisagree ", 7 = "" stronglyagree "). All questions were precoded and pre-tested with managers, academics and selected consumers. Using an inductive and qualitative approach including experiential in-depth interviews, we explored the salient factors of TI for decision support in New Product Development and Technological Innovation.

The Effective Use of TI to Support NPD

In this section we will discuss how to encourage NPD, especially how ideas are generated from superior information in the market.

Weak Signals and Signal Analysis

Information sources include the creation, production, storage, processing, and transmission of information. Information sources may be categorised based on many criteria, including chronological sequence, modes of transmission, and degrees of information processing. In the intelligence domain, information may be categorised by hierarchy and structure (e.g., fact, process, outcome, and trend), by the department or personnel responsible for its acquisition, based on content, by the medium, and by format.

Market signals manifest in several ways. It is necessary to rectify the reasoning in recognising and differentiating between authentic and spurious signals. The identification of credible information sources is essential. It must rely only on information from many sources to collect, regulate, compare, and evaluate for accuracy verification. Following extensive validation, a more dependable source of information may be pursued.

In the book "Competitive Strategy" [23], Michael Porter discusses the notion of market signals. Porter characterises a market signal as any activity taken by a rival that offers a direct or indirect indication of its intents, reasons, objectives, or internal circumstances. The conduct of rivals offers indications in several ways. Certain signals represent bluffs, others serve as cautions, while others are genuine pledges to a certain course of action.

Based on the volume of information indicating trends, signals may be categorised into strong signals and weak signals for the market. Day and Schoemaker [24] assert that weak signals are often ambiguous, inconsequential, imprecise, and interspersed with much "noise." Numerous weak signals are often obscured within events, data, text, and discourse, and mostly owing to insufficient empirical evidence and rationale, these weak signals have been disregarded. Despite their elusive nature, weak signals are crucial in competitive intelligence activities.

Furthermore, weak signals may not evolve into primary or accurate information in subsequent market developments. Neglecting these signals may result in the forfeiture of a market, missed developmental opportunities, or the loss of the ideal moment to address the issue.

Consequently, the aggregation and analysis of information has become imperative. Effectively identifying these subtle signs and responding promptly is a challenging endeavour. Facilitating tracking and acquiring further data and pertinent information to elucidate its significance will be very crucial. Schoemaker and Day [25] present a paradigm for evaluating weak signals to inform decision-making in the investigation of novel business strategies. Further empirical testing is required. These approaches will enhance predictive activity and early warning capabilities.

For any firm, receiving and transmitting signals may enhance the understanding of their competitive landscape and supremacy, enabling them to take necessary steps against competitors. A deficiency in signal identification and assessment methodologies will diminish the accuracy of forecasts and early warnings.

Weak signal analysis, particularly in the context of information collecting and analysis for high-tech companies, including technological foresight via numerous "signs," "clues," and other weak signals, merits additional examination and research.

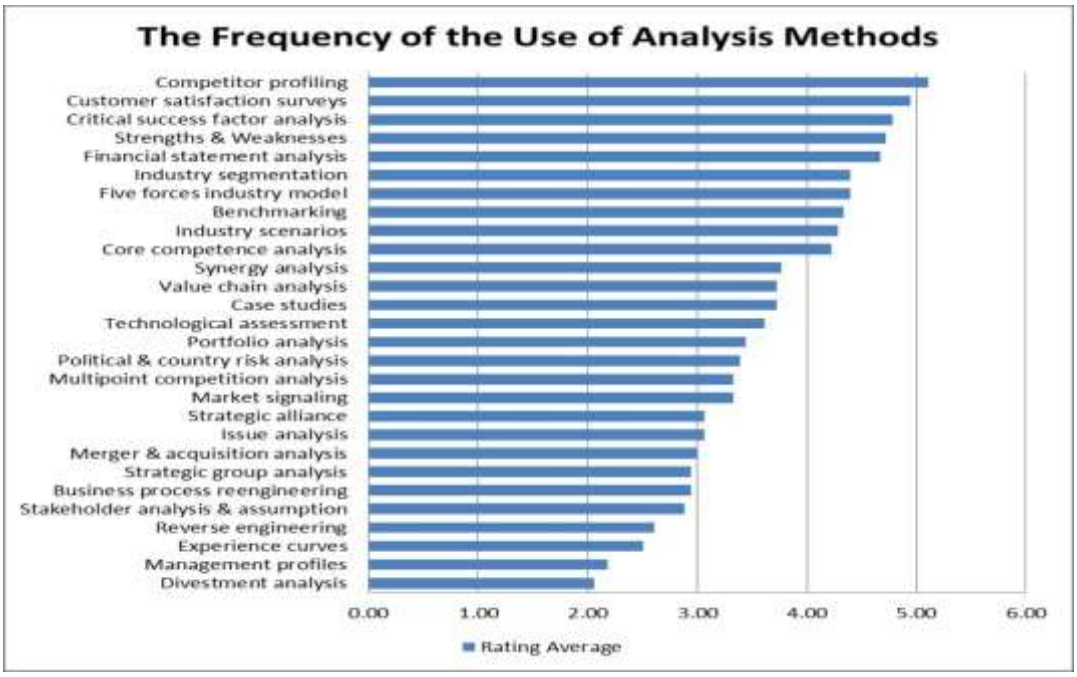

Fig. 2The Frequency of the Use of Analysis Methods

Capturing Reliable Sources of Technical Information

With the growth of network technology, information found by a quick search often has to be filtered because definitions and the sources of information are not clear. Specific methodology is first to be sure to verify the information by checking a number of different sources instead of relying on a single source. If there is only a single source, it is difficult to ascertain the truth. But by comparing with other sources of information, discrepancies can be noticed. Second, check the time the data was published. Third, analyse the relevance of the data as compared with other sources of information. If some inconsistencies are found, validating information from a third party is necessary.

The Ansoff matrix [26] is one of the most widely used marketing analysis tools that help businesses decide their product and market growth strategy. It takes the product and the market as two basic elements, shows the difference of four product / market portfolios (existing products - existing markets, existing products - new markets, new products - existing markets, new products - new markets) and demonstrates that corresponding marketing strategies require different technological information. According to the strategic direction and product development life cycle in different situations, the keys to information collection and analysis are also different.

Facts and trends

Technological facts and trends need to be grasped both from quantitative information and qualitative information. Upon considering in which area to introduce a new product, the causes of underperformance of the firm ’s products, or changes in positioning, the collection of information that forms the basis of judgement is essential. There are two types of information: quantitative and qualitative. Quantitative information is numerical data on market size, competing firms’performance, manufacturing lead time, per-capita labour costs, and so on. Numbers directly indicate ‘facts ’.

Qualitative information is information that cannot be numerically indicated, such as customer needs, competition ’s behaviour, new products’characteristics, organisational authority and dynamics, business flow, decision-making rules, and so on. Whereas quantitative information indicates ‘facts ’, qualitative information is useful in understanding the significance and the background of those facts. It can be observed, however, that in some cases, subjective opinions and judgements are included in qualitative information.

Therefore, by ‘making evaluations with the facts ’or by ‘combining facts and trends ’, opportunities and threats that are not easily recognizable can be discovered. In collecting information, it is also extremely important for a firm, in detecting market opportunities and understanding market trends, to examine not only information on customer needs, but also information on customers ’customers, competing firms ’behaviour in the market, and suppliers ’behaviour. In a previous study, the case study of Matsushita Electric Industrial Co. Ltd., suggests how important it is to obtain timely information [27]. In the case of Matsushita ’s TI activities, the collection of related information focused on opportunities resulted in a successful technology development strategy targeting a specific market.

Technology Analysis in NPD observed from the TI

Most pricing strategies for product and technology are formulated and implemented in mature markets. Innovation is most likely to occur in a mature market. When products in the market have matured and profitability falls to a certain level, it is very important to find the next area of new development and enter the new market quickly. TI is useful in analysing the state of products of product maturity and industry maturity. Understanding the present state of PLC can improve the efficiency of NPD.

Technology Life Cycle and Technology Maturity

Using a biological analogy, the PLC describes the evolution of sales as a function of time. This model asserts that, similar to all living organisms, a product passes through four stages: Introduction, Growth, Maturation and Decline stages. PLC describes the product in terms of its business/commercial costs and sales. There are four main stages of a product's life cycle, each stage specific characteristics. However it is difficult for marketing management to accurately identify where a product is located on its PLC graph.

Most new technologies follow a similar technology maturity lifecycle. Technology adoption typically occurs in an S curve. Depending on whether technology is in its emerging, growing, or maturation stage, the types of management challenges vary significantly. The importance of understanding the maturation of technology cannot be underestimated. It is possible to construct S curves for the technologies under examination. It is more important to understand how mature the technology is, and then to explore management implications.

The relative level of technology maturity is only part of the technical intelligence required. Where is the owned company? Where is the rival? When does the technology mature? Or, are there choices of technology? Is there a superior new technology? When will the new technology be commercialized? How fast is the technology evolving and who is driving the evolution of the technology? If the market switches to a new technology prematurely, investing in new technology is only a waste of money. It is important for management to make the right decisions and switch to new technology at the right time. Failure to foresee these changes may lead to serious mistakes. Figure 3 illustrates the key topics of technology intelligence.

Role and importance of TI corresponding to each stage of PLC

In the development of a new product or new technology, management must evaluate the discontinuous technological development apart from the saturated market. TI is playing a significant role in technology innovation. It is important to consider the life cycle and to ensure the state of technology maturity.

During the initial stage of market introduction, the role of TI is to identify and monitor potential competitors. It is necessary to identify alternate products and rival enterprises accurately. Once potential competition is identified, strategic planning is needed to assess the situation and to implement appropriate strategies.

During the advanced stages of growth and maturity, competitive threats may change in quantity and/or quality. During the growth stage, it is important for the enterprise to make certain adjustments. For example, if it is facing severe competition, it must restructure its marketing strategy.

During the seemingly inevitable decline stage, the TI professional will need to prolong profitability and to prevent as much market loss as possible. As a product life cycle draws to a close, the profit period can be extended by using alternate products or exploring new markets. TI practitioners can gather acquired market knowledge. These can be useful in future markets.

In summary, the role of the TI is to gather, analyse, and disseminate intelligence. This intelligence helps the enterprise maintain its competitive advantage throughout all stages of the technology life cycle.

CONCLUSION AND FUTURE RESEARCH

This research focuses on information sources and information analysis in Technology Intelligence to improve the accuracy of decision-making in NPD and technological innovation, under a condition of uncertainty. Effective management of information and Intelligence can make a huge difference to companies involved with NPD. Such management can improve performance of new products, facilitate the development of product concepts, and increase the success and frequency of crossfunctional activities among functions and departments. This paper presents the technology information sources demanded for NPD, and revealed the importance of technical information source selection and analysis through survey result. As a result, the Technology Intelligence-based decision support approach in NPD and technological innovation with competitive advantage is suggested.

Finally, this paper presented the technology analysis in NPD observed from the Technology Intelligence-based decision support approach. Future research will focus on the technology scouting and monitoring to seek weak signal of emerging technology and considering the stage-gates system as point controls for NPD risk management.

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