Technology Intelligence-based New Product Development -Fostering Technological Innovation with 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.

Key Words : Technological Innovation, New Product development, Technology Intelligence, Product Life Cycle, Competitive advantage

1. Introduction

Due to globalization and fierce market competition, the business environment is changing rapidly. In the development of a new product or new technology, design management decisions are highly complex and made under uncertainty due to increased levels of product complexity, changing customer needs, and shorter product life cycles. Generally, an 'innovation' is developing a new idea and putting it into practice. Technological innovation may be classified in several ways: product vs. process, radical (fundamental) vs. incremental (improvement), and disruptive vs. sustaining (sequential and / or complementary). Managing innovation better than its competitors is one of the main objectives of a business that wishes to survive and thrive in today's economy.

NPD (New Product Development) is the term used to describe the complete process of bringing a new product to market. The process could be divided into two main steps: the Fuzzy Front End (FFE), and the product development execution. The FFE is defined by those activities that come before the more formal and well-structured NPD process [1]. Even though there is a continuum between the FFE and NPD, the activities in the FFE are often chaotic, unpredictable and unstructured. Most companies define the concepts in the FFE and use the traditional "Stage Gate" [2] process in the NPD. Koen et al.[3] distinguish five different front-end elements: Opportunity Identification, Opportunity Analysis, Idea Genesis, Idea Selec-

tion, Concept and Technology Development. They include all activities from the search for new opportunities through the formation of a germ of an idea to the development of a precise concept.

Myers & Marquis [4] construct technical innovation models which addresses needs and technology. The new product development process begins with idea generation. For every successful new product, many new product ideas are conceived and discarded. Therefore, companies usually generate a large number of ideas from which successful new products emerge. The key point is how they generate new ideas and turn this idea into a commercialized product. For instance, regarding information on technology and customers' needs, information is collected and arranged by order of importance. As a result, a new technology may emerge to meet customers' needs.

For the success of NPD and technological innovation, firms must focus on the technology, market and competitive environments constantly in order to get information on environmental change and market responses accordingly. Sources for ideas about the market and whether new products will be successful include top management, sales representatives, customers, distributors, competitors of the company etc. It is extremely important to understand the concept and process of information and intelligence management before collecting, analysing, and evaluating the information. Intelligence can be defined as the capacity to obtain and analyse information which facilitates decision making.

Intelligent decision support relies on techniques from a variety of disciplines, including artificial intelligence and database management systems. However, most of the existing literature neglects the exact role of TI (technology intelligence) in relation to innovation. Although there is a vast literature on different technology intelligence methods, there is a lack of research

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on the factors influencing the choice of appropriate technology intelligence method. During the processes of NPD, the competitive information collection, analysis and utilization has not been fully carried out, because of a lack of practical application experience.

This paper highlights the important contributions made by the effective use of the different tools in the TI system to the process of taking innovative technologies to market, through launching of superior products and/or services. For the sake of simplicity, it focuses on TI as an important driver for enterprise competition, playing a significant role in technological innovation. It describes TI for decision support in NPD and technological innovation. It also discusses in detail the role of TI in each Product Life Cycle (PLC) stage. The objective of this research is to explore technical information sources to satisfy information needs for NPD decision making on the basis of TI theoretical studies, and to provide some initial insights into the decision support approach with competitive advantage.

The remaining of this paper is organized as follows. Section 2 elaborates on the literature review from information management and intelligence management related research. Section 3 presents an analysis of technology information sources and presents how intelligence is generated from information by analysed for NPD decision support. Section 4 takes on a more detailed discussion of effective use of Technology Intelligence to Support NPD. Section 5 presented the technology analysis in NPD observed from the Technology Intelligence-based decision support approach. Finally, a conclusion was developed on the basis of this analysis and highlights areas for future research.

2. Literature Review

The purpose of this section is to briefly review literature related to intelligence management and analysis methodology.

When discussing decision-making, first we must review the management information system and data processing supporting corporate decision making. The concept of supporting corporate decision making from a large number of internal and external data came in the mainframe era. In the 70s, MIS (Management Information System), and in the 80s, DSS (Decision Support System) provided the information needed to support decision making. In the 90s, DWH (Data Warehouse), OLAP (Online Analytical Processing), DM (Data Mining) and other data processing techniques have been developed. However, even data mining and OLAP still need some expertise or technical staffs to extract and process data. Since the beginning of 2000, the development of information technology has made information more visual with higher efficiency. BI (Business Intelligence) is used as the company's management information system, so that data savings, collection, and analysis can support business decisions. BI is used to analyse internal data and business processes, while CI (Competitive Intelligence) [5] gathers and analyses information with a topical focus on company competitors. Industry information, product information, technical information, is all necessary competition information in order to make a management decision.

Success in the introduction of a new product can be critical for a firm to maintain its competitive position. However, a variety of difficulties and uncertainties are associated with the new product development process. Firms invest in R&D knowing

that only a small percentage of promising product ideas will achieve commercial success. The use of CI to improve the identification and grasping of business opportunities, to provide effective support for strategic decisions, and to secure a new competitive advantage, are critical issues faced by modern enterprises.

CI enables senior managers in companies of all sizes to make informed decisions about everything from marketing, R&D, and investing tactics to long-term business strategies. Effective CI is a continuous process involving the legal and ethical collection of information, analysis and dissemination of feasible intelligence to decision makers. CI functionality requires that it be established by fitting a CI unit into the organizational structure of the company.

TI [6] or Competitive technical intelligence (CTI) [7], as a subset of CI, is an activity that enables companies to identify the technological opportunities and threats that could affect the future growth and survival of their business. Savioz [8] defines CTI as collecting, analysing and evaluating competitors' product or technology-related information, as well as timely delivery of technical facts and trends related to information technology management to support business decisions. Savioz chose a medium-sized enterprise in the medical technology filed in Switzerland, and found out a series of guiding principles for the foundation of TI in SMEs (small and medium size enterprises). Lichtenthaler [9]–[12] advocates TI depends on an organisation's decision-making style and its culture. He chose 25 multinational enterprises as research objects, and investigated the flow and analysis process of the information about the technology trends in corporations, the decision-making process of the managers about the technology trends, and the different roles of the TI analysis team in these processes. Lichtenthaler et al. [13] introduced a new concept, technology intelligence, referring to observing a particular setting and placing special emphasis on identifying technological licensing opportunities.

From existing literature, it can be summarized that the whole process of implementation from a CI/TI viewpoint can be considered as the collection of information on technology, monitoring, analysis, forecast, prediction and early warning, to describe the process.

In this research we aim to analyse how intelligence is used during their strategic decision processes in NPD. Then the firms may use TI to collect, analyse and evaluate information on the technology needed to enhance competitiveness.

3. 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.

3.1 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 tech-

nical 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.

3.2 Information Gathering

The government takes the initiative in actively providing information services to enhance the international competitiveness of industry. For example, in Japan, science policy and industrial development plans are settled on by the central government, and detailed technical roadmaps and implementation plans are created by independent administrative organizations, such as the Japan Science and Technology Agency (JST) and Japan's New Energy and Industrial Technology Development Organization (NEDO). They also have the long-term responsibility of tracking, monitoring, collecting and analysing the technical development to simulate growth of key industries. The reports of these government agencies include important information on a large number of technology trends. Based on government publications, national policy, activities, scientific and technological achievements and so on can be understood.

Scientific literature, papers and other documents of academic research are also a valuable source of technical information. Their contents are highly technical, of high quality, and they reflect the academic standards of professional disciplines, research developments and trends. Through exploring scientific literature and journal articles, we can understand the industry's level of basic research and results, and are enabled to grasp the direction of future technological development.

The information contained in existing patent documents / information plays an important role in the conception, screening and development of an idea. Such information can provide

useful insight into whether an idea is new or not and whether to proceed further in developing an idea. Furthermore, proper analysis of patent information may provide an insight into the strategy of potential competitors and about technology trends.

Generally the company will encourage employees to apply patents for protecting its intellectual property rights. Therefore, the analysis of patent information can help companies understand the situation of patent applications and developments in technology. But for high-tech products, in order to prevent leakage of product development projects, and to make the new product available in the market before competitors, patent application is often delayed or abandoned. Therefore, it has become more important to predict the trends of a competitor's product development, based on scientific literature and publications, to dig out industry and competitors' basic research strengths.

Some definite correlations can be found without relying on human experience and intuition, by using methodologies such as, data mining, artificial intelligence and etcetera. Through the patent literature and meta-analysis of scientific literature, a glimpse the whole picture from embryonic research to product development, then to commercialization can be obtained. As mentioned above, sources of information in accordance with the technical content of the signal intensity can be summarized and is shown in Figure 1.

In fact, the enterprise's employees in their various functional departments hold more valuable technical information, especially the technical reports, technical standards, product surveys, technical documents, test reports, manuals, newspapers, and company meetings, etc. Most Japanese companies pay attention to internal corporate information. According to the Japanese Ministry of Science and Technology Policy Research's innovation survey report in September 2010, the main source of technical information comes from internal groups, suppliers and customers. The ratio that takes the scientific literature and patent information as an important source of information is still very small. Obtaining information from an enterprise's internal group is a significant characteristic of Japanese companies, as much outside information has been converted into the enterprise's internal information.

Gathering and analyzing information in a timely and accurate manner can increase understanding of technological changes and trends and can also provide an early warning so that a company can avoid the situation of changes in technology becoming a threat to their business. As information technology continues to improve, and information visualization technology, intelligent retrieval, intelligent collection, data and text mining, information extraction, information filtering and other methods work in practice, TI has been widely used. However, this information must be based on reliable information sources. As technical information requires professional, reliable and useful sources, how to determine the reliability of the technology information is a critical issue.

3.3 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 in-

Fig. 1 Technology Information Sources and Signals Intensity

dustry 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.

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 = “strongly disagree”, 7 = “strongly agree”). All questions were pre-coded 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.

4. 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.

4.1 Weak Signals and Signal Analysis

Sources of information are those that involve the generation, production, storage, processing, and dissemination of information. Sources of information can be classified according to different ways, such as the chronological order of information, forms of communication, and information processing levels. In the intelligence field, they can be classified by hierarchies and structure, (ex: fact, process, result, and trend), by the department or staff who acquired the information, according to information content, by the carrier, and by format.

Market signals appear in many forms. There is a need to correct the logic in identifying and distinguishing between true and false signals. The selection of reliable sources of information is necessary. It must be independent of information from multiple sources to gather information, control, compare and analyse to verify its accuracy. After long-term verification, a more reliable source of information can be sought.

In the book “Competitive Strategy” [23], Michael Porter talks about the concept of market signals. Porter defines the

market signal as any action by a competitor that provides a direct or indirect indication of its intentions, motives, goals or internal situations. The behaviour of competitors provides signals in a myriad of ways. Some signals are bluffs, some are warnings, and some are earnest commitments to a course of action.

According to the amount of information revealing trends, the signals can be divided into strong signals and weak signals to the market. Day and Schoemaker [24] point out that the weak signals are often vague, irrelevant, uncertain, and mixed with much “noise”. Many weak signals are often hidden in phenomena, data, text and conversation, and mostly due to lack of convincing empirical data and logic, weak signals have been ignored. Though difficult to discover, weak signals are important in CI practices.

Moreover, weak signals may not develop into the main or even correct information in the follow-up market. However, if ignored, these signals may cause the loss of a market, loss of development chances or loss of the optimum time to solve the problem. Therefore, information collation and analysis has become necessary. Accurately capturing these weak signals and taking action at the right time is not an easy task. To support tracing and finding more detail and related information to clarify its meaning will become extremely important. Schoemaker and Day [25] propose an evaluation framework from weak signals into decision support on new business strategy exploration. It is worth further empirical testing. These practices will promote more activity of prediction and early warning.

For any business, getting and giving any signal can help to understand their competitive environment or their predominance, also be able to take appropriate actions against to their competitor. On the other hand, if there is a lack of signal identification and evaluation methods, it will reduce the accuracy of forecasting and early warnings. With regard to weak signal analysis, especially for high-tech industries’ information gathering and analysis, such as technology foresight in the various “signs”, “clues” and other weak signal analysis, it is worth further consideration and study.

Fig. 2 The Frequency of the Use of Analysis Methods

4.2 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.

4.3 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.

5. 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.

5.1 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.

5.2 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.

6. 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 cross-functional 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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Fig. 3 TI Topics on Technology Mature

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