Technology intelligence

Structuring it into the new-technology-based firm (NTBF)

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New-technology-based firms (NTBFs), with their flexibility and speed of response, have re-emerged as an important part of modern economies. They are in the vanguard of technological change, because of their ability to innovate. This article explores the literature on the subject of organization and culture of technology intelligence in an NTBF. It considers intelligence as an evolutionary process that grows with the firm. The article draws lessons from the literature and presents two case studies to show how NTBFs are making efforts to sytematize technology intelligence for competitive advantage.

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Introduction

Flexibility and speed of response are key advantages of new-technology-based firms (NTBFs), thanks to the knowledge base available with such organizations. To support sustainable growth, this knowledge base has to be properly structured and carefully cultivated. It is therefore of crucial importance to understand and classify the NTBFs knowledge management activities with regard to the development of appropriate methods, tools and processes. Information on market, product and technology changes, and on other environmental transformations must be obtained - from industrial and commercial fairs; from specialized or business publications; through links with (lead) suppliers or other business partners, governmental organizations and research centres, and consultants; or directly, from market observation through personal contacts, and recent and prospective customers. For this purpose, numerous companies have installed a so-called intelligence system (technology, business or competitive intelligence) to manage these observation activities, to analyze the information gained and, in order to increase decision-making quality, to communicate insight.

As organizational needs may differ in this regard, it is surmised that there are different ways to develop and implement technology intelligence activities, depending upon the business's environment, the uncertainty level, the strategy followed, and the resources controlled.

Another important factor influencing the NTBF's technology intelligence needs depends on the stages in the company's life cycle. During the initial

stages (initiation, survival and growth phase), startup firms are especially faced with rapidly changing technology management activities, and therefore, with changing technology intelligence needs as well.[1]

Given these premises, and using the results of several in-depth case studies by means of action research, this article aims to provide a better understanding of the development and implementation of technology management methods and processes in NTBFs. One must note that no attempt has been made to support these findings through empirical research, but the case studies are based on current findings and models from empirical literature. Here the assumption is that, as with many other NTBF practices, there is no one best way to maintain an organizational knowledge base through technology intelligence.

The next section reviews recent technology intelligence research and identifies elements of technology intelligence in the NTBF. These elements are validated and applied through two case studies.

Literature survey

Technology intelligence, understood synonymously as business and competitive intelligence, is a young management discipline - in literature as well as in industry. From a recent study on best-practice technology intelligence in large multinational enterprises, it is evident that enormous efforts are being made to establish structures and processes that aim at ensuring the vital inflow of relevant information.[2] The obvious question arises as to what measures should also be taken by (very) small and medium-sized companies which crucially rely on external information sources as well, but are notoriously limited in their resources.

While earlier studies assumed that SMEs tend to have little formal intelligence activity[3,4,5], more recent studies[6] show that these activities are nonetheless emerging in SMEs, and are not restricted to large firms. There is an assumption that there is "one best way" for these firms to scan their environment, using prescriptive models usually taken from large organizations[7,8], but these assumptions are too simplistic. [*Examples of how an intelligence system can be conceptually designed and implemented in technology-based SMEs are shown in Savioz.*[9]]

For an NTBF a standard description is even more difficult because of the entrepreneurial dynamics and cultures within these firms. The act of becoming an entrepreneur involves changing the external environment from one state (that without the venture) to another (that with the venture). It also represents a basic discontinuity in the competitive structure of the industry involved, and sometimes even results in the creation of an altogether new industry. This is a dynamic process, since both the venture and the industry of which it is a part, are evolving over time. It is also unique, since no other industry or competitive situation will be exactly the same.[10] Therefore, implementing a technology intelligence model from traditional firms and searching for "the" technology management approach does not seem very promising.

Instead, technology intelligence has to be looked at in a more generic manner, in order to be managed in the NTBF. One early study[11]distinguished four behavioral modes of intelligence activities: (1) "undirected viewing" (general exposure to information without specific purpose); (2) "conditioned viewing" (directed exposure to information without active search); (3) "informal search" (relatively limited and unstructured efforts to obtain specific information); and (4) "formal search" (deliberate efforts following a pre-established plan, procedure or methodology to secure specific information). Undirected and conditioned viewing can be referred to as "scanning", informal and formal search as "monitoring".

Similarly, it has been shown[12] that technology intelligence practices develop in four distinct types or phases: (1) the "primitive phase" (no specific effort); (2) the "situational phase" (awareness of the need to scan but no formal system introduced, or sporadic scanning); (3) the "reactive phase" (unplanned, unstructured activities); and (4) the "proactive phase" (rigorous, intensive practices).

One must also realize that NTBFs do not necessarily evolve in linear fashion from stage to stage. Certain stages can be bypassed when required in a rapidly changing situation. For instance, technology intelligence can take on added importance and become more complex when the firm's environment becomes more uncertain or hostile[13], particularly when strong threats emerge.[14] Other factors, such as the type of competitive advantage to be obtained by a firm[15,16], its level of technological development[17], the quality and level of education of its leaders[18], and its active participation in information networks[19], can differentiate the type or level of technology intelligence done by NTBFs. In other words, a "primitive" or a "situational" intelligence system can be perfectly justified if the information obtained allows the small firm to maintain or increase its competitiveness in a specific economic environment.

This literature survey leads to a consideration of technology intelligence activities under four dimensions[20]: (1) The objectives of the scanning activity; (2) The type of information sought; (3) The sources of this information; and (4) The practices used to manage this activity (Figure 1).

Firms can have various *purposes and strategic orientations* when scanning and monitoring their environment. Some researchers suggest that performance is the primary motivation for scanning[21,22,23], while others insist on objectives related to competitiveness and strategic advantage[15,16], or production and productivity objectives.[4] Depending upon these objectives, various types of information will be collected and processed. Researchers have indicated that this information relates to financial and human resources, product and process innovation, and marketing.[24, 4]

The second and third component relate to the field or domain to which technology intelligence is applied. The questions raised in these areas concern information types and the sources used to obtain information. *Information types* are generally classified to distinguish the different disciplines of intelligence (technological, commercial, competitive, strategic) and scope (scanning versus monitoring).

With respect to *information sources*[21,25], personal (informal) sources, such as customers, staff, business contacts, suppliers, competitors, research centres, etc., are distinguished from impersonal (formal) sources, such as business publications, fairs, brochures, magazines, newspapers, databases, etc. The NTBF mainly uses personal resources[26] through informal channels (telephone contacts, personal discussions, etc.).

The last component of technology intelligence in NTBFs refers to *management practices*. The questions generally raised here concern staff participation (versus hoarding of information by the entrepreneur), the methods used (simple or complex), the organization of technology intelligence management, the level of formalization and frequency of intelligence activities, and the inclusion of intelligence in strategic management. In general, technology intelligence activities revolve around the owner-manager[27], and simple methods tend to be better known and more in use.

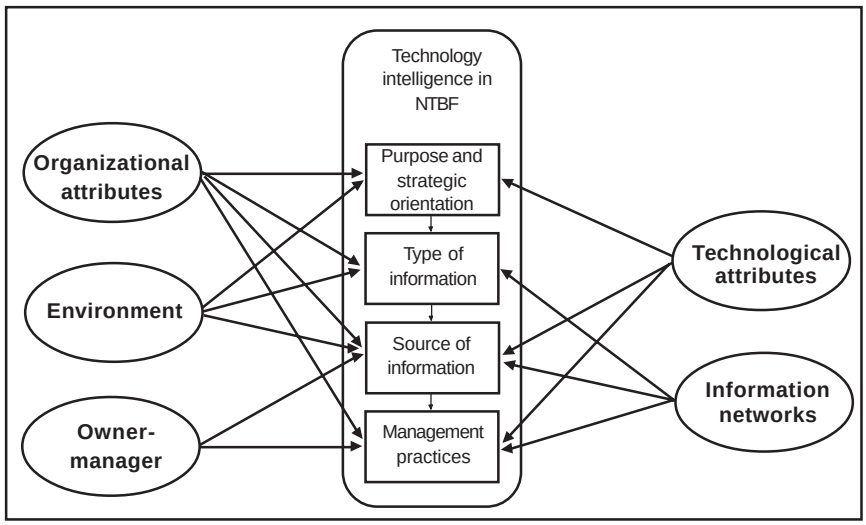
A significant positive influence on the use of methods was the company's experience, the number of employees, the complexity of products and the number of employees with a background in large companies.[28]

Next to the dimensions of technology intelligence in NTBFs, the literature also indicates five influential factors: (1) Organizational attributes of the firm; (2) Technological attributes of the firm; (3) Owner-manager attributes; (4) Environmental attributes; and (5) Participation in information networks (Figure 1).

Organizational characteristics, such as the firm's size and organizational complexity, are presumed to have an effect on technology intelligence[12] The most notable of these characteristics is the firms strategy.[29] In this regard[30], the typology of strategic behaviour (firms classified as being reactive, defenders, analyzers, or prospectors) is most relevant to technology intelligence.

Technological attributes, such as the sophistication of the firm's production and its research and development (R&D) capability, are also deemed to play a determining role.[20,31]

Figure 1: Dimensions and influential factors of technology intelligence in NTBF (adapted from reference, 20)



In regard to the *owner-manager attributes*, the level of education is less influential than the professional management experience and experience in the sector.[18] The founder's behaviour strongly influences the NTBF's culture, and hence also the technology intelligence management practices.[32,33]

Uncertainty and turbulence in the *environment* were found to be exogenous factors of the environmental attributes, affecting scanning objectives, and types and sources of information.[20]

The presence of, and access to, *information networks* (inter-firm networks, universities and governmental agencies) has a positive impact on technology intelligence, especially for types and sources of information.

Lessons

On the basis of this literature survey, an explorative research design was developed to gain insight into technology management practices in the NTBF. To gain a better understanding of dimensions and influential factors of technology intelligence, action research projects were carried out in cooperation with two Swiss NTBFs. Action research is designated as an approach in which practitioners and scientists jointly plan and implement new organizational concepts. In turn, the scientists involved try to systematize and generalize their experiences.[34]

In the first of the following cases, a technology management system has been designed and implemented over a two-year period, which results in a deep understanding of the evolution of the firm, and also of technology intelligence. The second case shows a complete example of elements in a decentralized technology intelligence system.

Case studies

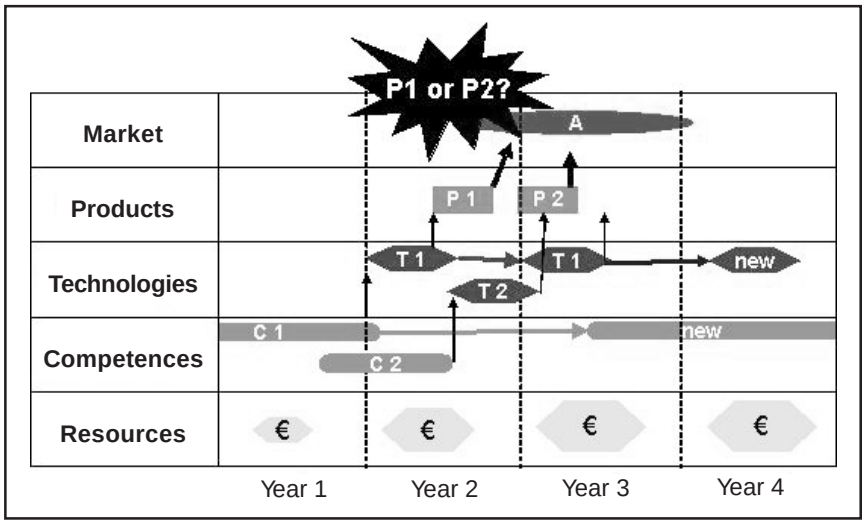
Case study 1: Degradable Solutions (DS)

Company description

Start-up: DS was founded at the beginning of 1999 as a spin-off company of the Swiss Federal Institute of Technology (ETH) in Zurich. The founder and some of the first employees have worked over a longer period in the field of degradable biomaterials at the Chair for Biocompatible Materials Science and Engineering. Today, DS employs nine persons in the vicinity of the ETH.

Focus of activity: DS specializes in the development and manufacture of degradable medical implants. A balance between pursuing their own product ideas and contract development is maintained. Their clients are medical and pharmaceutical companies throughout the world. DS approaches the market in cooperation with strong distribution partners. The goal of DS is to develop inno-

Figure 2: Information gap visualized through a technology roadmap



vative medical therapies and to substitute permanent implants through the use of degradable solutions for the benefit of patients.

Technologies and products: With the *Calc-i-oss* and *Root Replica* product lines, DS has introduced an advantageous and ideal alternative by offering implants made of degradable materials. After fulfilling their therapeutic function, they degrade and are reabsorbed by the body. No additional surgery is needed. Typical application areas are dental or orthopedic applications; e.g. wound therapy after tooth extraction.

Business strategy: DS aims to be a global supplier of degradable implant technologies and products. This should be achieved through an incremental internal growth in close cooperation with external partners.

Evolution of technology intelligence

Right from the beginning of DS, the management identified a few areas that needed to be watched carefully, corresponding approximately to the situational phase. Before the incorporation, in order to set up a business plan, the founder had to estimate the feasibility of the project and to acquire early projects (Figure 2). For this purpose, a market survey was carried out and possible opportunities and threats were identified.

The most important source of information was the professor, who played an important supporting role during the whole start-up process by providing valuable information and motivation, as well as by opening doors to partners and clinicians.

In a short period of time, the knowledge coming from customer projects turned out to be a potential new source of valuable information that could easily be harvested. This information gathering process took place without specific tools or formal organization.

After a few years in business, the intelligence system turned from the situational phase to the reactive phase. More projects and investments as a result of continuous growth require a more formalized strategic planning process. Strategic planning requires an understanding of the environment, and specific information needs can be articulated.

Technology intelligence takes on a more important role as efforts are made to seek specific information. Especially rare is market information about detailed future customer needs as well as competitor information. The challenge is to anticipate the clinic's and the patient's true needs to select the most promising projects and develop products that are likely to be in demand. For reasons of confidentiality, only a few trusted clinical partners are consulted.

Technology intelligence management practice is closely related to strategy planning. Future technology and product development projects are sketched on a simple roadmap, purely technology-driven. In a next step, the management has to estimate which functions the customer is willing to pay for.

In order to determine this, detailed information from the market is helpful and a focused technology intelligence process is launched. Lead customers of DS are surveyed with a detailed questionnaire.

Case study 2: Zeptosens

Company description

Start-up: Zeptosens started its operations in March 1999. The multidisciplinary Zeptosens team - with a scientific background in physics, chemistry and biology - provides the skills and know-how to efficiently develop analytical nanotechnologies and methods as complete solutions. Today, Zeptosens employs 28 persons. Zeptosens is located in the Technology Centre Witterswil, in close proximity to Basel, in the tri-national Swiss/German/French region.

Focus of activity: Zeptosens envisions initiating a new era in highly multiplexed, automated and ultrasensitive biomolecular analysis on nanotechnology-based microarrays and readout systems. Zeptosens is developing and will introduce highest sensitivity detection technologies for the analysis of a few hundred molecules on a micro-array. With the Zepto™ technology, the industrial user will obtain a tool to measure nucleic acids at the highest sensitivities, with the capability to determine families of proteins all at once in order to gain rapid insight into biological processes, and to use this information for efficient product development.

Productline and technology basis: With the Zepto™ product line, Zeptosens is introducing a new revolutionary fluorescence-based detection technology for nucleic acid and protein microarrays. This will set new standards in micro-array readout performance in terms of detection limits, quantification and automation. The initial products will be tailored for gene expression monitoring, even in minute quantities of tissues, such as biopsies, and for multiple, simultaneous determinations of immuno-analytes, such as biomarkers. Typical application areas will be in life science R&D. The current core detection technology is based on the pla-

nar waveguide principle, an approach backed by eight years of R&D by the founder team in an industrial environment. Zeptosens has access to a broad range of IPs and know-how in optical detection technologies, nano technology, micro-fluidic designs, miniaturized bioassays, and surface chemistry.

Business strategy: The strategy is to provide academic and industrial customers with complete bio-analytical solutions that will enable them to obtain information on critical parameters faster and with higher quality, thus enabling them to make decisions more efficiently and more reliably. For marketing and service, Zeptosens relies on the competencies of established partners.

Technology intelligence system

Zeptosens management is continuously concerned with the question of "what's next?" Therefore, they run a formalized technology intelligence system. There are several elements of this system that will now be illustrated: the 'business developer', the 'technology watch' and the 'business strategy meeting'.

Business developer

This person is charged with scouting for 'deals' in proteonics, that is, business opportunities, which may also be research collaborations. However, these collaborations are expected to later on result in turnover.

Through such scouting activities, the business developer comes in contact with numerous scientists, and thus with new technologies. Because of his scientific background in chemistry, the business developer is able to analyze technical information. This insight is transferred to other employees informally and formally by means of official meetings, such as the weekly team meeting (*see also 'technology watch' below*).

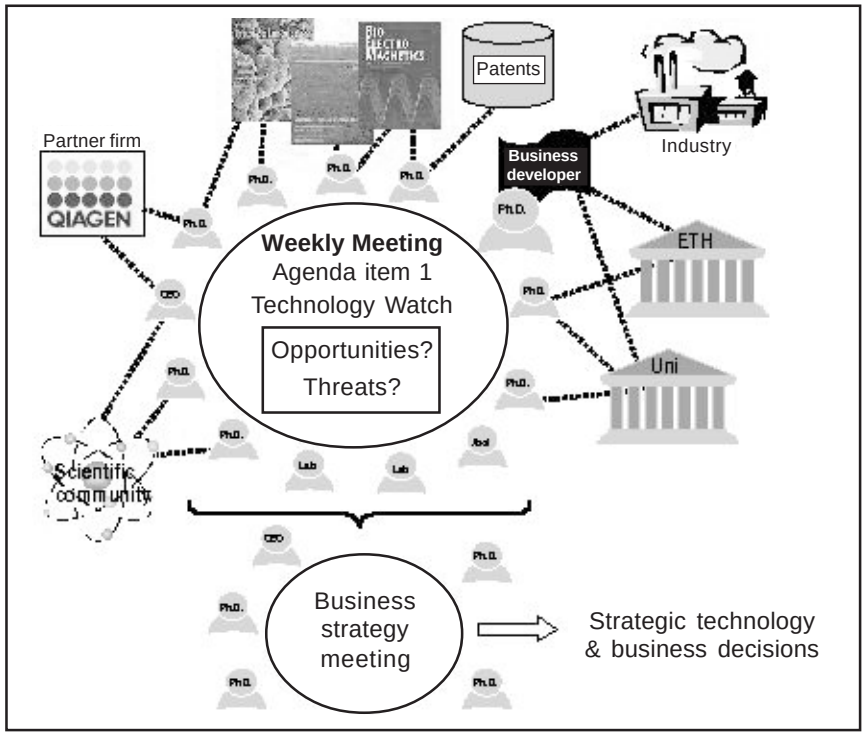
Technology watch

The major technology intelligence element is an agenda item in the weekly team meeting, named "technology watch". This deals mainly with one question: "Are there potential opportunities and threats in the technological environment?"

To answer this question, each employee contributes with knowledge built during daily work. Some employees have specific tasks. By the very nature of his work, the business developer is one of the main actors in the technology watch. In addition, there is one person working entirely on patents, which also makes him a specialist in knowledge about new technologies. Other employees have formal tasks, which may be as a project leader in research collaboration, or as a direct link to a partner firm. Yet more employees contribute with knowledge from periodicals, internet searches, informal networks, etc.

In this way, each employee has an entrepreneurial responsibility. An enormous advantage of such a 'forced' exchange of trends about the technological environment and the emerging ideas is the greater pace with which the company can act on them, the increased knowledge base, and hence the potential innovations.

Figure 3: Technology Intelligence System at Zeptosens



Business strategy meeting

Another element is the monthly business strategy meeting. In fact, insight from the technology watch is processed, and strategic decisions are made based on the generated intelligence. A particular point is the fact that, next to the CEO and the heads of the teams, any interested employee may participate in this meeting. The only condition is that participants must also contribute actively to the meeting. This makes business strategy a democratic affair.

System overview

These elements together build a technology intelligence system (Figure 3). In fact, there is a defined process that allows Zeptosens to be informed about trends in the technological environment. The process can be described by the value-creating scheme. The institutionalized agenda item and the scouting mission of the business developer represent technology intelligence mission and goals. Some roles are explicitly allocated; other activities are executed informally and democratically by all employees. A particular characteristic is that top management is fully integrated in all technology intelligence activities, which means that any employee, if interested and competent, may participate in decision-making.

Conclusion

The aim of this article was to survey the literature on the subject of technology intelligence and thence develop

models to serve as guidelines for practitioners. The two case studies illustrated how technology intelligence may be implemented and applied in an NTBF. They helped to understand different factors and influences on technology intelligence management practices. These research findings have been further validated with a set of interviews covering 13 NTBFs, mainly in the biotech, meditech and IT/electronics industries. What is remarkable are some of the accidental details that have played an essential role in the development of a firm. It is clear that there is no one best way to undertake technology intelligence; instead, there is a large number of situational best solutions for gathering external information on a formal or informal path. Irrespective of the kind of solution, it is clear that to look at technology intelligence in the context of the firm opens the way for the improvement, development and application of organizational models and supporting tools.

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