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ScienceDirect
Research Policy 36 (2007) 387–398
research policy
www.elsevier.com/locate/respol

Patent indicators for the technology life cycle development

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Received 15 January 2006; received in revised form 14 November 2006; accepted 29 December 2006
Available online 20 February 2007

Abstract

Investments in a technology have to consider its current life cycle stage. The widespread approach of studying technology life cycles by measuring patent activity indices, especially patent applications, raises a practical problem: it requires the survey of all applications and applicants on a technological field. On the basis of an empirical study on pacemaker technology the paper identifies several patent indices as appropriate life cycle stage indicators which do not require the survey of the complete patent activity.

Keywords: Technology life cycle; Patent indicators; Pacemaker technology

1. Introduction

The attractiveness of a technology as an investment object depends decisively on its current life cycle stage. It is a widespread approach to study *technology life cycles*[3] by observing the *evolution of patent applications* (e.g., Achilladelis et al., 1990; Achilladelis, 1993; Andersen, 1999).[4] There are good reasons for this approach (e.g., Debackere et al., 2002, p. 216). First, patents inform us about the technological development itself since they contain the technological know-how. Second, they inform us about the commercial potential of a technology because the possibility of commercial use is one of the preconditions of patentability. Third, data about patent applications (from an ex-post-perspective the annual number of applications of granted patents) inform about the technology life cycle also before life cycles of different products, which are based on the technology, can start.[5] Last but not least, patent applications can be measured easily and objectively by using data banks. Due to these advantages it is reasonable to prefer patent application data as basis of technology life cycle descriptions to accumulated sales generated by products made possible by the new technology.[6]

Corresponding to product life cycles we can differentiate introduction, growth, maturity, and decline as technology life cycle stages—regardless of what the

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[3] Concerning the concept of technology life cycles see, e.g., Mansfield (1961); Silverberg et al. (1988).

[4] Patent activity is also used to describe life cycles at the levels of products (e.g., Gort and Klepper, 1982; Agarwal, 1998) and industries (e.g., McGahan and Silverman, 2001).

[5] In this way, they provide us with information at the early stages of research and development (in the terminology of Ford and Ryan, 1981; these are the first two of six stages, named "technology development" and "technology application").

[6] Of course, we have to consider that in some technological fields patents are not the preferred method of protecting technological knowledge—a topic we can and will not deepen here.

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doi:10.1016/j.respol.2006.12.004

reference factor is, and regardless of the fact that a patent-based life cycle starts earlier than a sales-based one.

Several empirical studies show that a *S-shape-evolution* of the number of patent applications or even a *double-S-shape* is typical (e.g., Achilladelis et al., 1990 (with examples from the chemical industry); Achilladelis, 1993 (with examples from the pharmaceutical industry); Andersen, 1999).[7]

There is consensus on the interpretation of this specific S-shape of application evolution (e.g., Campbell, 1983a, p. 143). In the beginning of a new technology's development (*introduction*) fundamental scientific and technological problems have to be resolved. This is the time of radical innovations. Therefore, the number of patent applications is low, only slowly increasing. Since there is typically only a small number of pioneer firms as patent applicants which are willing to bear the R&D risk, the concentration ratio (patent applications per applicant on a certain technological field) is typically high. Coping with the basic technological problems as precondition for developing marketable products can last so long that the development of patent applications stagnates or even declines towards the end of the technology's introduction stage. Other possible reasons for such a temporary stagnation or decline can be: innovative products are still too expensive, the customer acceptance is still low, the range of technology application possibilities is not clear yet (e.g., Callon, 1980), or the "dominant design" (Abernathy and Utterback, 1978) has not evolved yet.

When the basic technological and market uncertainties have vanished, a broad range of market applications of the technology can be developed. Innovations become less radical. The R&D risk decreases. Therefore, the number of patent applications increases. The technology's *growth* stage begins. Despite the growing number of patent applications per year, the concentration ratio decreases typically because new competitors – i.e. patent applicants – appear.

In the following phase of *maturity*, the number of patent applications – then typically incremental innovations – remains constant. After that, when the potential for new product innovations on the basis of the technology and therefore the number of annual patent applications decreases constantly, the technology's *decline* stage begins.

Since the S-shape (in the case of a temporary stagnation or decline: double-S-shape) of *applications* could be observed in so many cases, this patent activity index is to assess as a *valuable indicator of the current technology life cycle stage* in a concrete case. An observer can find out the current phase by examining the shape of application evolution until the present time.

However, a technology observer, trying this, has to face *a practical problem*. The measurement of patent applications (in general of patent activity) requires the complete statistical survey of all patent applications and applicants of the considered technological field. With regard to most technologies this survey is difficult or even impossible—despite modern patent data banks. The reason is that the international system of patent classification (IPC) does not offer classes exactly corresponding to a certain, product-related technology. Moreover, most technologies cannot be identified with a clearly defined set of technical search terms.[8]

Thus, it would be very interesting to find *patent indices* which show typically different values at each life cycle stage of a certain technology – like the application index – *without requiring the complete survey* of all patent applications and patent applicants belonging to this technology. Patent indices of this kind would be appropriate technology life cycle indicators like the proven activity indices.

By pursuing this objective, we benefit from the fact that there are some rare technologies that allow a complete survey of patent applications (and applicants). So, concerning a chosen technology of this type (we will choose pacemaker technology), we can and will determine the *durations of the life cycle stages* on the basis of the proven indicator of patent applications. Then, we test if other selected patent indices, which do not require the complete survey of applications, also show typical different values at the identified life cycle stages. The indices which will be tested require only the survey of the applications of the *two main competitors on a certain technological field*. An average observer should succeed in identifying these two firms and their applications after a short insight in a technological field.[9]

[7] Andersen studies life cycles of 56 technologies while she is not measuring the evolution of absolute annual numbers of patent applications but of the accumulated patent stock (depreciating it over a 30-year-period). In her approach patents of a technology are separated just on the basis of USPTO code numbers. Thus, she manages to identify the patent data base of such a great number of technologies but cannot avoid that typically patent classes do not correspond exactly to technologies (e.g., "Code 39: Other general electrical equipment" (p. 492)). In contrast to that, Achilladelis et al. (1990) and Achilladelis (1993) identify the patents belonging to a technology by analysing the patent abstracts.

[8] A minor, but nevertheless hindering problem is that sometimes the same technological object is described by two (or more) search terms: e.g.: "diods laser" and "laser diods".

[9] The first step is the identification of all patents of the two main competitors by data bank analysis. Then technical experts have to identify