Technology readiness assessment in terms of financing reaserch and developement projects

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Abstract. The methodology to assess technology readiness is currently the key instrument in supporting the decisions to finance research and development projects. It was originally used in the area of aviation and space technologies, where the requirements connected with reliability and resilience to extremely difficult conditions are very high. Nowadays the methodology is used in Poland in the evaluation of research and development activities related to commercial market that is characterized by massive diversity. The need to apply this methodology in the process of commercializing new products is indicated in this study.

Key words: Technology Readiness Levels, commercialization, innovation, product life cycle, financing research and development projects

INTRODUKCION

The main source of wealth of countries and nations comes from manufacturing in such a form that would allow us to find purchasers. This requires a constant search for new products that will replace those which are in the final stages of their life cycles.

RECENT RESEARCH AND PUBLICATIONS ANALYSIS

The studies presented in the literature refer mainly to the technical aspects of the TRL methodology [4, 5, 6, 7, 9, 11, 13, 15, 17, 18, 20, 21]. However, there are not many studies describing the TRL methodology in terms of commercialization of new products and their potential financing.

OBJECTIVE

The aim of the paper is to present the TRL methodology in terms of commercialization as well as the development of new technological solutions, and possibilities of obtaining funds from EU operational programmes.

MAIN PRESENTATION

Figure 1 shows the classic life cycle in terms of production engineering, considering the linkage with life cycles of previous and next products. This linkage makes it possible to raise finance for the development and introduction to the phase of growth and maturity of the subsequent products.

- Development- the idea for a new product is generated (sometimes it is an invention), its design and production technology is developed. The implementation capacity is analysed, prototypes that are to be analysed and evaluated are created. Production in terms of technology and organization is prepared.
- Introduction- the beginning of production, activities on improving the product and the manufacturing process. Measures aimed at improving the quality level, e.g. FMEA, control cards. Determining corrective actions, creating maintenance documentation. The beginning of work on developing the next product.
- Growth- increasing production capacity, minor changes to the product and manufacturing technology, strengthening and developing quality systems. The development of the service networks. The development and beginning of the phase of launching new product.

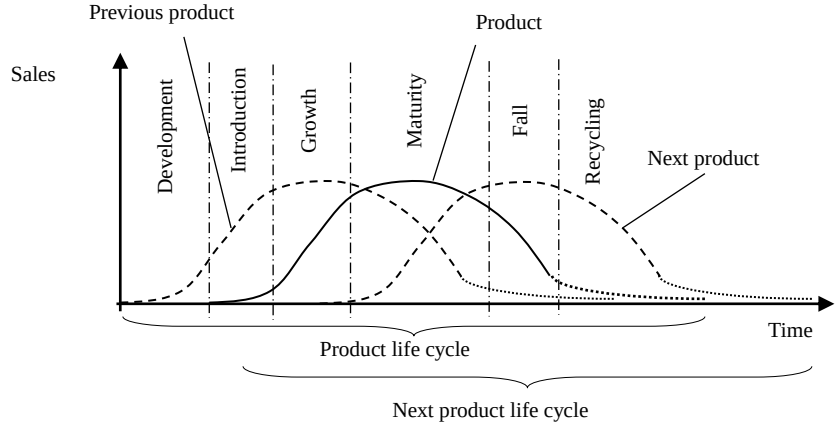

Fig. 1. Product life cycle
Source: [9, p. 8].

- Maturity- maintaining appropriate production capacity, changes and modifications of the product to increase its attractiveness. Effective use of quality systems. Launch and the phase of growth of the next product.
- Fall- maintaining the decreasing production, providing resources for carrying out maintenance tasks after the end of manufacturing the product. Gradual adjustment of manufacturing resources to manufacture other products. The maturity phase of the next product [9].
- Recycling- retirement and cassation, in which the waste product is separated into elements, and thus obtained materials are used again in different ways. Care for the environment often forces, already at the design stage, conducting LCA (*Life Cycle Assessment*), which involves the evaluation of the product impact on the environment throughout its entire life cycle including the use of resources in the processes of production, use and disposal.

Each subsequent implementation of the product life cycle is verified by the market at the interface of the seller and buyer. There occurs a relationship between them, which involves the point of interest "what" and the mode of operation "how" (Fig. 2).

The relationship on the part of the seller illustrates the issue of commercialization: what and how to launch on the market in order to sell. The answer to the question "what" is the beginning of the commercialization process and it is connected with the problem of innovations and innovation. The times when the land value, followed by coal, was the highest belong to the past. Nowadays it is knowledge and creativity that are the most valued, which leads to inventions and innovative solutions and is the only way to enter the path of rapid economic development.

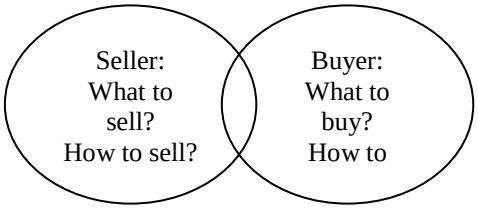

Fig. 2. The relationship between the seller and buyer
Source: [9, p. 10]

In these days of rapid development the answer to what to produce in order to be successful on the market is of particular significance. This may be a completely new product, or a currently manufactured product which has been altered. The transition from the stage "what" to "how" is a long process of launching. In this process called commercialization we can distinguish several basic stages, whose task-oriented illustration is in (Fig. 3).

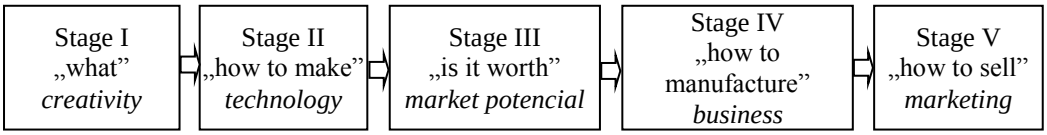

Fig. 3. Task-oriented commercialization process
Source: [9, p. 11-13]

Stage I – search for answers to the question: what to produce. Ideas are necessary, their generation requires creativity. Ideas originate thanks to creativity, however not all of them have the chance of reaching the end of the commercialization process. This is the most difficult stage, despite the fact that there exist various methods supporting the non-effective procedure of generating new ideas to ensure market success later.

Stage II – answers the question of technical feasibility of manufacturing the product. So this is a business area of engineering, without going into the details related to the design and technology. An overall assessment of the feasibility of the product is conducted, taking into account the expectations of potential customers. In a production environment unforeseen operating conditions [12, p.165] This stage requires the involvement of the designers, engineers and technologists in collaboration with marketing specialists.

Stage III – answers the question about business success, namely what has a decisive influence on the final decision about manufacturing a product or withdrawing from production. For that purpose the market potential is evaluated (otherwise known as the implementation or commercialization potential). The outcome of the evaluation supports the decision to continue or stop the commercialization process (Fig.4).

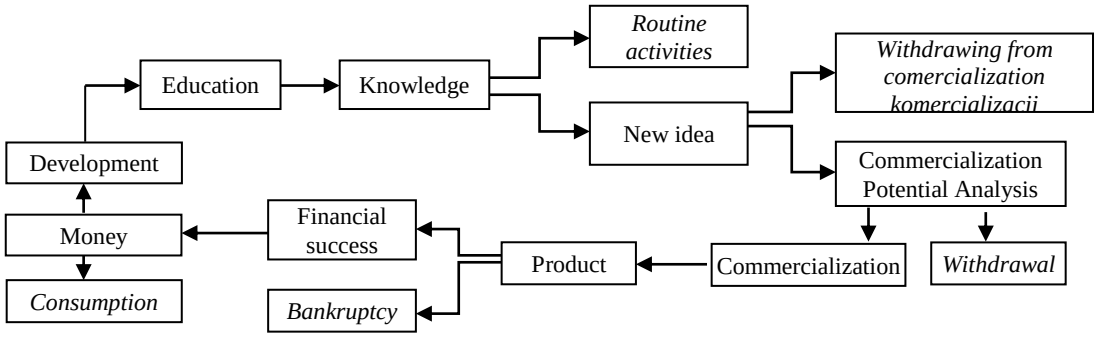

Fig. 4. Development loop: New idea - commercialization
Source: the authors' study based on [2, 13].

The loop indicates activities and events promoting or inhibiting the development process. The transition to new technologies requires significant costs associated with the upgrading of knowledge [3]. Education provides a man with knowledge that fosters creativity, which can be the source of new ideas. Learning can be formalized: in the form of school and higher education of the first, second and third degree, it can also be a non-formal process of learning.

Most knowledge is consumed for routine activities, while sometimes it effects in an innovative concept transformed into a new idea or invention, some of which are subject to commercialization. The decision of commercialization should be supported by an analysis of the commercialization potential. In contrast, the result of the commercialization process is the launch of a product. A sufficiently large number of sold new products leads to financial success.

Otherwise the commercialization process is not considered successful and can lead to bankruptcy. Financial success brings money which can be spent on consumption and development, closing the loop and starting a new cycle of learning combined with research and the emergence of new ideas.

Stage IV – is conducted after a positive decision about continuing the commercialization process and answers the question: how to manufacture the product. This is often implemented as a very large operation, whose aim is to prepare the production of new products. Nowadays this type of enterprise is carried out in the form of a project, taking into account the principles of project management.

This may be the classic PMBOK Guide methodology (A Guide to the Project Management Body of Knowledge), which contains a set of standards and solutions in project management, collected and published by the PMI (*Project Management Institute*) members [22]. It is a combination of activities in the field of engineering expertise and business operations.

Stage V – is associated exclusively with business knowledge, and it is based on marketing activities. At this stage it is necessary to identify potential markets for the new product and interest from prospective customers, as well as an indication of distribution channels.

The scheme illustrated in Figure 3 is consistent with the description presented by V.K. Jolly [8], who is considered the father and precursor of commercialization issues, and a frequently applied Cooper model. According to this description there are five stages in the process of commercialization, in which the subsequent stages were named and grouped in a slightly different way.

Finance plays a key role in the process of creating, developing and commercializing products. In many cases it is necessary to invest a lot of financial resources and lack of them or insufficient quantities are the main reason for resigning from commercialization or absence of final success. Financial needs grow rapidly in the subsequent stages of the commercialization process. It is assumed that the costs of stages II and III are at least ten times higher than the cost of stage I. On the other hand, the costs of stages IV and V are at least ten times higher than those of stages II and III. Figure 5 presents the distribution of costs depending on the stage of the commercialization process that is implemented.

Stage III is followed by a sharp increase in costs and the so-called „Death Valley" begins. The second slope of the valley is the end of stage V, when the marketing activities connected with the sale of a product are closed. The commercialization process comes to an end and costs associated with it decrease. At the same time there appear the first revenues from sales, corresponding to the growth phase.

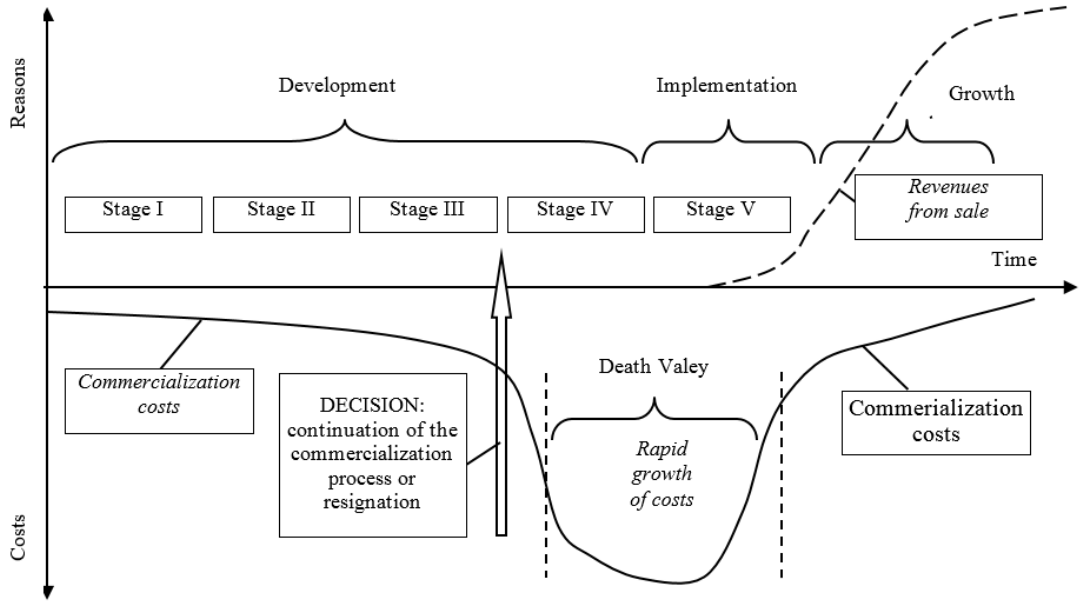

Fig. 5. Financial flows in the commercialization process
Source: the author's study

This rapid increase in costs causes numerous failures in the commercialization process. Therefore, before entering this stage the analysis of the commercialization potential, which takes into account the technical and business aspects, should determine the chances of success. The results of the analysis are the basis for making rational investment decisions. The assessment of the technology readiness may be a useful element in such an analysis in the part concerning the technical aspects.

Technology Readiness Levels are an instrument which makes it possible to determine the level of maturity of new technology showing innovative features. Technology is understood here as a manufacturing technique or as a product.

TRL constitutes a uniform metric used to analyse the status of work on technologies and their readiness for commercial implementation and is a key element in the assessment of investment projects relating to research and development [17]. The TRL methodology does not refer to the full process of commercialization, for example, it does not answer the question whether there is demand for the product or technology under assessment.

It is promoted as a tool for assessing research project co-financed by the European Union. For the practical application a certain scale was defined (Fig.6). The scale is represented by nine levels of technology readiness (Technology Readiness Levels) that are a reference model using a common measure, which makes it possible to assess the progress of work on new technologies. [15]

The TRL methodology was first used in R&D projects implemented by NASA and the US defense industry. According this methodology the maturity of technology is described from the phase of the idea of a specific solution (TRL 1), until the stage of maturity (TRL 9), when this idea as a result of research and development takes the form of a technological solution that can be applied in practice, e.g. by starting production and launching it on the market.

PRODUCT

9	Functioning technology tested in operating conditions with positive results (production)	Demonstration in commercial terms
	Technology after the closing stage and final qualification	Product Demonstration
	Presentation of the prototype work in the operating conditions	
	Presentation of the technology prototype operating in real-like conditions	
	Concept validation in real-like environment	
	Concept validation in lab	Technological research
	Experimental proof of concept validity	
	Formulation of the technology concept	
	Specification of the basic principles of operation	Basic research

IDEA

Fig. 6. Technology Readiness Levels
Source: the author's study based on [10 p. 108].

Currently, the TRL methodology is used in the assessment of research and development activities related to a commercial market characterized by a large diversity. This may result in a low efficiency assessment, especially in the absence of an explicit procedure of matching the current state to the levels indicated in the methodology.

This methodology is used by the Polish state organizations (e.g. National Centre for research and Development) in making decisions about subsidizing research programs.

The initial applications of the TRL methodology was aimed at assessing innovative designs related to technology transfer. However, there is no explicit reference only to the issues of innovation. This is partly due to the lack of commonly used tools and methods to assess innovation.

The so far applied binary assessment (innovative/non-innovative) does not account for the type of innovation, which makes the assessment difficult. This could be solved by applying a multi-stage scale of enterprise innovation level and by taking into account the technology readiness assessment applied by the enterprise and conducted according to the TRL methodology for evaluating the state of technology development [9,10].

There exist no unambiguous procedure of matching the current state with the levels indicated in the methodology, which may result in low efficiency of the assessment.

CONCLUSIONS

The methodology to assess technology readiness is currently the key instrument in supporting the decisions to finance research and development projects. Using one method requires taking into account the phases of the product life cycle process of commercialization of innovation funding. As the principal I can be used for assessment of TRL.

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