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Science in Business

Technology and Market Readiness Levels

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Abstract

Technology is widely considered a key driver for innovation and sustainable business growth. However, existing methods for examining and tracking the progress of individual innovations are almost exclusively focused on the technological aspects of development. Although more recently, the importance of readiness for market has been increasingly recognised, there remains a need to better monitor individual innovation with respect the market potential so that this particular risk can be better defined and appropriately resourced in a timely manner.

We introduce a mechanism for assessing market readiness, which provides a complementary perspective on innovation and technological development, that enhances market-led innovation and improves market orientation for technology-led research.

Background

Because technology is a key driver for innovation and sustainable business growth, a great deal of effort and resources are expended on R&D in both the private and the public sector. In the UK, the Research Councils support £3 billion of research each year in our research institutes and universities. The latter is underpinned by the dual support system with funding from the education budget covering the cost of university staff. UK Businesses spent £15.6 billion (2009 figures), with the largest source of R&D funding provided by businesses' own funds to the value of £10.1 billion, 64.5 per cent of the total. Funding of R&D in UK businesses from abroad was £3.4 billion, 21.4 per cent of the total. The UK Government's funding of businesses' R&D was £1.2 billion, 7.9 per cent of the total, and predominantly in defence (ONS, 2009). Monitoring and guiding the use of such resources for the development of new technologies is seen as crucial to successful exploitation of innovation, especially in large multi-disciplinary projects.

A means of improving the effectiveness of this substantial investment would yield significant rewards in terms of the development of leading technologies with more targeted impact meeting market need, and leading to increased sustainable business growth.

Technology Readiness Levels

The concept of Technology Readiness Levels (TRL's) has been developed as a tool to assist in monitoring technology development and is now very familiar in the innovation lexicon. The term originated with NASA in the 1980's in order to help management make decisions concerning the development and transitioning of technology (Sadin, Povinelli, & Rosen, 1989).

Level 1	Basic Principles Observed and Reported
Level 2	Potential Application Validated
Level 3	Proof-of-Concept Demonstrated, Analytically and/or Experimentally
Level 4	Component and/or Breadboard Laboratory Validated
Level 5	Component and/or Breadboard Validated in Simulated or Real Space Environment
Level 6	System Adequacy Validated in Simulated Environment
Level 7	System Adequacy Validated in Space

The basic scale has been modified over time through use in the space, energy and transport industry as well as the military, with most systems now recognising nine levels, and extending its value to other spheres enabling organisations to demonstrate their role in the process of technology development e.g. the UK Technology Strategy Board (http://bit.ly/o3vUUy)

Systems Readiness Levels

TRLs have the benefit of providing a common understanding of the status of a technology in its development pathway, a means of assessing and managing risk, and decision making concerning funding and implementation of technology.
As with any management tool, there are certain limitations and disadvantages to its use. These include the creation of extra reporting, paperwork, reviews, lengthy adoption times across an organisation, and particularly, lack of integration with systems integration and engineering approaches (Gove, 2007; Mandelbaum, 2007; 2008, Sauser *et al.*, 2008). Failure of a technology to integrate into existing systems can severely limit or delay its introduction and implementation.

As Baines (2004) made clear, the wrong technology, or even the right technology poorly implemented, can be disastrous. Such understanding led to the development of the concept of System Readiness Levels (SRLs) originally proposed by Sauser, Verma, Ramirez-Marquez and Gove (2006), a scale that incorporates the maturity level of the critical components and the interoperability of the entire system.

Innovation Readiness Levels

Building further on this more holistic systems approach, recognising that successful and sustained innovation involves challenges rooted in technological uncertainties, ambiguous market signals and embryonic competitive structures, Lan Tao, Probert, Phaal (2010) looked at improving managerial approaches to innovation through the introduction of Innovation Readiness Levels (IRL). Their IRL seeks to provide improved monitoring and control based on a framework depicting the development of an innovation over its lifecycle. A process which identified five key aspects of innovation, namely; technology, market, organisation, partnership and risk, all of which influence effective implementation of innovation over different phases of an innovation life-cycle.

Of these five key aspects identified by Lan Tao *et al*. (2010) two are key drivers of innovation, namely technology and the market, while the other three are modifying and constraining variables to their exploitation: risk, organisation and partnership. Risk is of particular interest because although only considered in terms of "Technology Risk" by Tao and colleagues, i.e. that associated with the probability of the science and engineering being able to deliver a technological solution to the particular problem; there is also an additional risk which is too rarely considered - that of a "Market Risk". This is the risk that the technology being developed does not meet a market need. Hence, in developing a technology then "Technology Risk" is managed through the process of monitoring and control with TRLs but the corresponding "Market Risk" is not taken into account. This raises the question as to whether there is a need for a means to monitor and control technology development in relation to "Market Risk", one that mirrors the TRL capability - say a "Market Readiness Level". Then by analogy, research and analysis of the market should identify innovations for which there will be a corresponding "Technology Risk" associated with their development.

Demand Readiness Levels

Paun (2011) working with ONERA, the French Space Laboratory, considered this dual need and proposed as an additional scale to Technology Readiness Levels, the introduction of Demand Readiness Levels (DRL's), to relate to the degree of maturity for the need of an innovation by the market. Paun (2011) defined a DRL as "a new measure to assess the maturity of evolving demands by potential innovation actors towards an appropriate stage of conceptualisation of the need in the market, allowing a matching point with scientific research teams capable to either propose as solution an existing scientific result through technology transfer process or translate the demand in new R&D projects". Importantly Paun saw the use of the two reference systems, one for "Technology Push" and the

Demand Level	Demand Readiness Level	Technology Readiness Level	Technology Level
1	Occurence of feeling "something is missing"	Market Certification and Sales Authorisation	9
2	Identification of specific need	Product Industrialisation	8
3	Identification of the expected functionalities for new product/service	Industrial Prototype	7
4	Quantification of expected functionalities	Field demonstration of whole system	6
5	Identification of system capabilities	Technology Development	5
6	Translation of the expected functionalities into needed capabilities to build the response	Laboratory Demonstration	4
7	Definition of the necessary and sufficient competencies and resources	Research to prove feasibility	3
8	Identification of the Experts possessing the competencies	Applied Research	2
9	Building the adapted answer to the expressed need in the market	Fundamental research	1

Demand Readiness and Technology Readiness Levels (after Paun 2011).

other one for "Market Pull" combining to provide essential decision making information and to predict the state of implementation and commercialisation of a technology.

Market Readiness Levels

There is much of value in Paun's approach, although there is yet scope for refining the definitions used in the DRL scale (Dent and Pettit in preparation) and we would recommend the use of the term "Market Readiness Levels" (MRL's) as a simpler and complementary axis to Technology Readiness Levels. In defining DRL's Paun has attempted to create market entities in an identical mechanism to those relating to technology. However, unlike the technology axis, where development milestones are passed most commonly in a time-linear fashion, innovation development in readiness for the market comprises components, that although sometimes milestones, may not be necessarily passed in a similar chronological manner. Both TRL's & MRL's do however, share the same important characteristic, in that the extent to which their components are satisfied increases the chances of commercial success for any particular innovation.

Combining components of market readiness into a scalar number would permit interpretation equivalent to that which can be drawn form TRL's. This makes the market readiness approach more meaningful and practicable as a monitoring and control tool in business, and particularly valuable in terms of the assessment of risk (Dent and Pettit in preparation).

Conclusions

This paper highlights how although a great deal of effort has been invested in technological research, its funding and its management, as epitomised through the use of TRL's, there has been less emphasis given to understanding the market into which these technologies may be integrated and taken up. Market Readiness Levels and their potential use provide a different, market oriented perspective on innovation and technological development that will enhance market-led innovation and improve market orientation for technology-led research.

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