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Investing in new materials: a tool for technology managers

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Abstract

A technology management tool has been developed to determine the attractiveness of a materials innovation by systematically assessing the technical and economic viability, along with the likelihood to capture profits created. The Investment Methodology for Materials (IMM) may prevent companies from pursuing investment strategies destined for failure. Small and medium sized enterprises (SMEs), often started by the inventor of a new material, have had particular difficulty in commercialising new materials—either due to the upfront and risky expense involved in displacing an incumbent material in a mature industry or due to the need for complementary innovations to enable a radical innovation.

IMM helps identify promising materials innovations at an early stage, helps to direct research and development in directions most likely to lead to successful exploitation, shortens the gestation time of materials substitution and guides investment strategy. IMM adapts existing and emerging predictive software tools and business strategies to materials innovations, linking them to give a practical, comprehensive procedure. It consists of three interwoven strands: *viability analysis*, *market assessment* and *value capture*. For SMEs this technology management tool would be most easily applied by an outside consultant over a period of approximately one month.

Keywords: Materials innovation; Methodologies for SMEs; Commercialisation of new materials; Seed capital investment; Viability analysis; Market assessment; Value capture

1. Introduction

1.1. Technology management methodologies developed for industry

The need to combine good technological and business judgement is the driver behind th0e development of most technology management tools. These are practical techniques, usually decision support processes, that assist managers of technology intensive firms in evaluating the many factors that need to be considered in coming to soundly based plans of action (Brady et al., 1997). Typical examples of such tools and techniques are technology strategy formulation processes (Stacey and Ashton, 1990), technology roadmapping methodologies (Phaal et al., 2000), R&D project selection techniques (Phaal et al., 2000; Neely, 1998) and new product introduction processes (Cooper, 2001; Gardiner et al., 1998). In recent years many such processes and tools have been published, as managers seek structured ways of dealing with these complex issues. The many factors that need to be integrated into such an approach result in a high information requirement, and an associated high demand on company resources to fully implement the approach. As a consequence, they are usually designed for use in larger corporations, in which project teams can be assembled drawing on a wide range of knowledge from the various functions represented in the business: manufacturing, engineering, R&D, marketing, sales, finance, purchasing, etc.

However as the contribution of small firms to innovation has grown, so has the interest in adapting technology management tools for use in small businesses. National Government programmes in the UK and more broadly in the European Community have specifically sought to provide support to small and medium sized enterprises (SMEs). For example, the recent Technology Foresight programme in

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the UK has had a particular focus on the small firm, and has developed methodologies which are relevant in this context (Future Markets–Future Business, 1998). SMEs are seen to be central to wealth creation; but have particular difficulty in accessing and applying many of these technology management tools and techniques. There are some particular characteristics of SMEs, including a narrow focus on very specific technologies, a limited infrastructure, and concentration of knowledge in the heads of a few key individuals, which make the application of these tools and techniques a challenge. Successful technology management techniques aimed at such firms need to allow for these characteristics and resource limitations.

2. Materials innovation: a technology management challenge

For the last two decades, new materials have been identified as a source of revolutionary technologies (Tidd et al., 2001; Coates, 1998; Wield and Roy, 1995). Yet the introduction of new materials innovations to the marketplace is a technology management challenge that has been poorly addressed to date, particularly among SMEs. The greatest barriers to rational technology management of new materials innovations have been: (1) the time period that has traditionally elapsed between the discovery of a new material and its successful introduction to the market embodied in a product, and (2) the very large cumulative investment that is usually necessary to develop the innovative material to the point at which it can be commercialised. Both these barriers mitigate against the small firm pioneering materials innovations, and there has been very little published that can help small businesses to overcome these barriers. The technology management tool developed in this paper provides support to businesses of all sizes in evaluating the potential of a materials innovation: however, special care was taken to ensure this technique could be useful to SMEs by limiting the employee time and resources needed to use the methodology and by clearly defining the procedure to be followed.

2.1. Slow adoption of new materials

Innovation in new materials[1] has been characterised by a long gestation period between the technical invention and the first commercial application, and a long substitution period between the first commercial application and the widespread use of the new material. Polyethylene, Sheet Moulding Compound (SMC), Metglasses (amorphous metals), Metal Matrix Composites (MMCs), and technical ceramics for mechanical applications (SiC, Si_3N_4) are all examples of new materials innovations which have gestation periods of 20 years and above (Maine, 2000).

The length of the gestation and substitution periods of new material innovations are as long as they are due to many factors, often including an initially high cost invention, cost barriers to materials substitution from entrenched materials, and insufficient knowledge of market applications by inventors. We surmise that this long gestation period is partly due to a mismatch between designers' and entrepreneurs' understanding of market needs and the development of new materials for various applications. This mismatch is exacerbated by the many layers of separation between material and end consumer. Freeman likens the market push and technology pull of technological innovations to a pair of scissors (Freeman, 1982): together, the parts work efficiently; separately, they do not work at all. Assuming this matching process is a bottleneck in the diffusion of a materials innovation, a methodology to facilitate the matching of technical possibilities with the market could directly shorten the gestation period of materials innovation and substitution.

Adoption of new materials innovations is also slowed by strategic corporate decisions at the firm level. Much of innovation in materials industries has been developed and commercialised by large enterprises with structured R&D strategies. These organisations generally follow some sort of portfolio management system in order to diversify risk in the R&D projects that they fund and develop. However, due to flawed R&D valuation methodologies, the desire to match R&D tightly with current core competencies, and the reluctance to cannibalise current business, some potentially profitable materials innovations are passed over by large enterprises (Neely, 1998). Small enterprises escape some of these constraints, but have faced financial barriers to entry in commercialising a materials innovation over the past several decades, since long-term R&D investments, manufacturing equipment investments, market information, and distribution channels all benefit from the scale economies of large materials companies.

2.2. Need for materials investment analysis tool

One of the main barriers to smaller firms commercialising materials innovation has been access to capital for 'risky, long-term development' (Wield and Roy, 1995). Empirical evidence suggests that connectivity and the trend towards collaborative research are making access to capital less difficult (Maine, 2000). If the gestation time of a materials innovation can be shortened by these forces and technology and market risks can be lowered by tools and methods of research enabled by IT, the risk/reward position of materials

[1] This paper concerns innovation and adoption of new materials. In it, reference is often made to the 'materials industry', by which is meant the sector involved in the development and commercialisation of new materials. Factors common to companies in the materials industry include: high knowledge intensity; significant R&D expenses; production of an intermediate, non-assembled product; need for substantial investment in production facilities; need to interact with designers of downstream companies; ability to protect innovations with patents; economies of scale; and, in many cases, common buyers.