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Technology cross-fertilization and the business model: The case of integrating ICTs in mechanical engineering products

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ABSTRACT

This paper investigates the increasing interdependency among different bodies of knowledge in products, from the technology opportunities arising from 'cross-fertilizing', and how firms try to appropriate economic value from their technical potential. The study is based on three multi-national corporations, and their integration of information and communication technologies into established mechanical engineering products. The case studies show how technology cross-fertilization needs to be accompanied by business model changes in order to achieve increased economic value. While much attention has been given to the input dimension of multi-technology products, the economic and commercial domains have been rather ignored in previous literature. This work contributes to the management literature by linking the input resources with the market output for creating and appropriating value from technology cross-fertilization.

1. Introduction

It has long been recognized that diversification is a key strategic variable in firm growth[1] (e.g. Ansoff, 1957; Penrose, 1959; Rumelt, 1974; Montgomery, 1994; Markides and Williamson, 1994). Within this perspective, diversification of output markets, i.e., new product lines, businesses and geographical markets (internationalization), by utilizing economies of scope and resource sharing, has been the main focus. More recently, a new stream of literature on diversification has emphasized the importance of diversification of firms' input technologies in their output markets, for the growth of the firm (Kodama, 1986; Pavitt et al., 1989; Granstrand and Sjölander, 1990; Patel and Pavitt, 1994; Granstrand et al., 1997). This literature on technology diversification has made major advances in showing that large firms make use of, and develop, competencies in many different technological fields. The literature argues that the major driving forces of technology diversification are the opportunity to introduce new technologies into products by cross-fertilizing technologies, and the pressure to support a given product line to maintain its relevance (Granstrand et al., 1997). In so doing the literature emphasizes that products have to incorporate an increasing range of technologies (Pavitt, 2001). Much of the existing research on technology diversification focuses on the breadth of firm's technological competencies, often measured by the distribution of patents across technological classes (see e.g. Pavitt et al., 1989; Granstrand et al., 1997; Patel and Pavitt, 1997; Gambardella and Torrisi, 1998; Garcia-Vega, 2006), but downplaying the links with integration of new technologies into products, to value creation and value appropriation.

Creating and appropriating value from diversification in the technology base of products, i.e. technology cross-fertilization, is not automatic; innovative management is needed for their realization. Hence, from a managerial or firm perspective, a crucial aspect is how firms create value for their customers and how firms appropriate economic value. Technology cross-fertilization does not inherently lead to improved customer or user value. Nor does increased user value inherently lead to increased value appropriated by the integrating firm. Thus, creating and appropriating value from diversifying the technology base of products clearly needs to be managed. The cross-fertilization may create a potential value for some users, but to realize that value, and also to appropriate a part of that value, are potential management problems, arguably closely associated with the activities in the business model employed. This paper focuses on these areas with the aim of adding to the current limited empirical understanding.

This paper explores how the integration of Information and Communication Technologies (ICTs) into the technology base of a product can open up new sub-spaces in the existing technical performance and functionality space. The rapid and persistent improvement in the performance and cost of ICTs provides abundant opportunities for products to capture, control, process, store and communicate information in a way that was not possible before. In other words, old mechanical engineering products

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[1] Another commonly held view is that (unrelated) diversification reduces risk.

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increasingly have the potential to become more 'intelligent'. We investigate this technology cross-fertilization and look at how firms try to appropriate economic value. We conduct in-depth analyses of attempts to integrate ICT components into existing mechanical engineering products, undertaken by three different multi-national, multi-product and multi-technology corporations (MNCs/MPCs/MTCs): (1) for decanters in the area of wastewater treatment plants; (2) for industrial compressors; and (3) for ball bearing housings.

The paper is structured as follows. The first part provides the empirical and theoretical background. This is followed by a description of the methods and an investigation of three corporations that diversified the technology bases of their products by integrating ICTs. The paper investigates their attempts to create and appropriate economic value from these efforts. The paper concludes with a discussion of the findings and some managerial implications.

2. Theoretical and empirical background

2.1. Multi-technology firms and products

Today, a substantial number of products across all sectors incorporate several technologies, components and sub-systems. Both products and firms are becoming increasingly multi-technology, such that the technology bases of large firms are usually much larger than their product bases (Patel and Pavitt, 1997). Given this trend towards greater technological competition, firms' resource bases have had to become more comprehensive in order to support their product range. At the same time, firms have been obliged to specialize in a narrower range of production, because of the difficulties involved in sustaining the range of resources required to support a wide range of basic production areas. Penrose (1959) foresaw this situation, which was clearly demonstrated by Gambardella and Torrisi (1998) in the electronics industry and by von Tunzelmann (1998) in the food industry.

It has been argued, and amply demonstrated, that even the most vertically integrated firms need to access external resources in order to be able to exploit their inhouse resources when developing multi-technology products. It is not efficient for firms to produce everything involved in the manufacturing and product design of multi-technological products, when the production of technologies and components is concentrated in dedicated producers. They are forced to rely on external suppliers, sometimes even for the development of simple products. Thus, in many instances firms could be termed 'systems integrators' (Davies, 2003, 2004; Hobday et al., 2005). However, Granstrand et al. (1997) found that large firms increasingly develop technological competencies in a wide range of technological fields outside their 'distinctive core', i.e. those technologies that are dominant within the firm, and beyond those fields in which they have associated production activities. In other words, even if a particular technology is not part of the firm's core field it might be necessary for the firm to develop some in-house competencies in that area to enable it to coordinate its production systems and the supply chain, and to evaluate and handle technological opportunities. Brusoni et al. (2001) argued that it is necessary for firms to develop technological competencies without associated production, when the product encompasses highly interdependent components or subsystem whose interaction cannot be predicted, or when there are uneven rates of change in components or sub-systems. This latter aspect explains why over time firms acquire competencies in new technologies and why this is necessary (Pavitt, 2001). For large firms in particular, there is a tendency for them to broaden their competencies to encompass new, fast-changing science and engineering based fields (Pavitt, 2001), in order that the technologies can be incorporated into existing products to improve their performance and functionality (Granstrand et al., 1997).

2.2. Technology cross-fertilization

Adding new technologies to the technology base of a particular product is associated with a search process in which new technologies are explored, and then integrated into the technology base, resulting in enhanced technical performance along the existing trajectory and/or new functionalities. This process is sometimes referred to as product related technology diversification[2] (Granstrand, 2001). Here, the search for new technologies is constrained by the need for them to cross-fertilize within the product, opening up new sub-spaces in the technical performance and functionality space. This is another type of economies of scope that is different from cost-related economies of scope resulting from resource sharing (Granstrand, 1999).

Advances and breakthroughs in science and technologies open up opportunities for interdisciplinary combinations of different technologies (Granstrand, 2001). Cross-fertilization occurs, in particular, with the use of so-called general purpose technologies (GPTs) (Torrisi and Granstrand, 2004), which by definition are highly pervasive and cross most industry boundaries, being in many ways highly complementary to other technologies. GPTs act as enabling technologies by opening up new opportunities rather than offering complete product solutions (Bresnahan and Trajtenberg, 1995).[3]

ICTs are classified as GPTs since they can be combined with a multitude of other technologies. It has been shown that firms patenting outside their core technical domain increasingly do so within the ICT field. In fact, this field attracts more patents than any other, and therefore is increasingly dispersed across different sectors (Mendonça, 2002). Technology advancements in this field have been continuous, especially in terms of improved price/performance and new applications, and economic advantages of speed, flexibility, networking and storage (Freeman, 1995). As Freeman (1995, p. 55) states 'it would be a mistake to think of ICT simply as a set of new fast-growing industries. It is also a potent source of transformation in older "traditional" industries, such as . . . mechanical engineering'. Studies on inter-industry spillovers have focused on things such as productivity gains, the use of ICT in manufacturing and product design, cross-border knowledge flows, information exchange, workforce flexibility, organizational practices, process improvements, and economic growth (see e.g. Freeman, 1995; Helpman, 1998; Pavitt, 2001; Fabiani et al., 2005). Despite the fact that ICTs facilitate and can be utilized to improve established products, few studies, have studied their impact on established products, building on different engineering principles. This is somewhat surprising since ICTs have wide-ranging applicability for many different products in many different industries, resulting in both technical and business opportunities for firms, from the combination of these often

[2] The reverse of product related technology diversification is technology related product diversification, meaning that for a given technology base, new products are integrated into the product portfolio (Granstrand, 2001).

[3] One aspect of this, which is more focused on the generic technologies themselves and not the existing products, is discussed by Kodama (1992), which states that the fusing of existing technologies (technology fusion) can create so-called "hybrid technologies", e.g. fusion of mechanical and electronics technologies, which produced the mechatronics revolution, and the fusion of optics and electronics which created optoelectronics (the first would be characterized as production fusion and the second as scientific fusion, Freeman, 1995). These technology fusions gave rise to new products that revolutionized markets. Kodama (1986) ascribed much of Japan's success in the 1980s to its achievement in fusing science based and mechanical engineering technologies.