



## On the interaction between the growth process and the development of technical knowledge in young and growing technology-based firms

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### Abstract

This paper investigates the tensions that exist in young and growing technology-based firms between (1) increasing technological opportunities for further growth and (2) the costs of developing these opportunities.

Data from 70 medium-sized, young technology-based firms were used to test two hypotheses concerning changes in the number of separate fields of technical knowledge during growth. Increasing the number of separate fields of technical knowledge increases the technological opportunities available to the firm, but increases the cost of developing and integrating knowledge from multiple fields.

The results indicate that tensions between technological opportunities and the costs of technological development in young technology-based firms are created due to both the advances in science and technology and the firms' growth process itself.

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### 1. Introduction

The successful establishment and growth of new technology-based firms have been widely studied within the field of entrepreneurship research (e.g. Bollinger et al., 1983; Cooper, 1986; Roberts, 1991; Kazanjian and Drazin, 1990; Oakey, 1995). Despite considerable interest in the growth of new technology-based firms, few researchers have investigated what may be the most specific nature of technology-based firms as compared to other business firms, namely their dependence on technical knowledge.

In a recent review, Autio (2000) observes that few models have been developed specifically for explaining the growth of new technology-based firms and argues that, if the growth of new technology-based firms is a phenomenon that warrants a separate study, more research should be aimed at investigating the link between technology and growth in these firms.

The research reported in this paper is an attempt to answer Autio's call for more research on the interaction

between technology and growth in new, or young, technology-based firms. The selected approach is inspired by the competence-based and evolutionary views of the firm put forward by Foss and Knudsen (1996) and Montgomery (1995), and by Penrose's (1959) theory of growth of the firm. According to these views, firms are creative entities, the outcomes of ongoing processes of organizational design that provide a framework for creating and combining different kinds of productive knowledge. Understanding knowledge, organization of knowledge, and its subsequent changes therefore become the main explanatory challenge (Metcalf, 2001) in explaining both firms' competitiveness and their opportunities for further growth.

The purpose of this paper is to investigate the interaction between growth and the development of technical knowledge in young technology-based firms. More specifically, the paper investigates the tensions in young and growing technology-based firms between (1) increasing technological opportunities for further growth by increasing the number of separate fields of technical knowledge developed within the firm, and (2) the costs of developing and integrating knowledge from multiple fields.

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Previous studies have identified tensions between technological diversification and increasing R&D costs in large technology-based firms (Granstrand and Sjölander, 1990; Granstrand, 1998). Empirical evidence (Kodama, 1986; Oskarsson, 1993; Patel and Pavitt, 1998) shows that large industrial firms are accumulating competencies in an increasing number of technological fields. This process is driven by progress and increased differentiation of scientific and technological activities. The increase in the number of technological fields increases both the R&D costs and the technological opportunities that can be utilized to cover these costs. The challenge of management is to balance the tension that exists between costs and opportunities in favour of growth and profits (Granstrand, 1998).

In this paper, it is argued that similar tensions exist in young and growing technology-based firms. But rather than being driven by growth or changes in science and technology, it is argued that these tensions are inherent in the growth process of young technology-based firms and are amplified through growth or changes in science and technology.

The paper is structured in the following way. First, a frame of reference is developed on how the growth process and the development of technical knowledge jointly influence changes in the number of technical knowledge fields. Two hypotheses are derived and tested to help us understand the role of the growth process in creating tensions between the costs of technological development and future opportunities for growth. Second, the method and sample used for testing the hypotheses are described. Third, the results of the statistical analysis are presented, followed by conclusions and discussion.

## 2. Frame of reference

The concept of the new technology-based firm has been used in a number of different ways (Bollinger et al., 1983; Storey and Tether, 1998; Autio, 2000). Most definitions stress the newness of the firm and the intensity of internal research and development.

This study refers to young and growing technology-based firms. These are recently established technology-based firms that have achieved reinforced growth, i.e. internal pressures are exerted for further growth (Garnsey, 1998). As technology-based firms, they rely on the technical knowledge of employees for the creation, detection, and exploitation of business opportunities (Granstrand, 1998). They are likely to contain a specialized collection of technical knowledge related to their focus of activities. This collection of technical knowledge is extended and refined by a group of employees specialized in such activities. This group of employees are referred to as technical employees in this paper, and it is the development of their knowledge that this paper focuses on.

In the sections that follow, the proposed interaction between the growth process and the development of technical knowledge is developed. In the first two sections, changes in the number of knowledge fields are investigated: first, by investigating the growth process and second, by investigating the process of technology development. Finally, two hypotheses are proposed based on the expected interaction between these two processes.

### 2.1. The process of firm growth

Penrose (1959) describes the process of a firm's growth as recurrent periods of expansion of the firm's resource base and administrative structure. This expansion is based on productive opportunities identified by the firm's entrepreneurs and the managerial capacity to plan and carry out the exploitation of these opportunities.

The ability to identify new productive opportunities is dependent on the knowledge of the firm's entrepreneurs. Penrose (1959) argues that this knowledge will increase during expansion and that firms will always have new possibilities and inducements for further expansion, even if external conditions are unchanged. For technology-based firms, this means that technical knowledge available to the firms' entrepreneurs will increase during growth, making it possible to identify opportunities for further growth.

Further growth may be within existing areas of specialization (technology and markets) or through diversification into new areas with different combinations of new and existing technologies and markets. While diversification may make firms less vulnerable to abrupt changes in their environments, it puts a strain on the firms' resources, especially in competitive and technologically progressive environments. This restricts the number of fields that a firm can support at any given time (Penrose, 1959, pp. 104–152).

As firms grow larger, the number of formal structural components, such as levels and divisions, are likely to increase within existing areas of specialization (Penrose, 1959; Blau, 1970). This increases the division of labour, which is linked to knowledge development. Not only is increased division of labour conducive to the development of knowledge, but more knowledge will also increase the possibility of further, or different, division of labour (Loasby, 1998). There is therefore a possibility of positive feedback between division of labour and knowledge.

Parallel to increased division of labour, knowledge becomes increasingly specialized and differentiated within each structural component. The attainment of feedback between division of labour and knowledge, and its value for the firm, is therefore dependent on the administrative structures used to coordinate the development and use of knowledge across multiple structural components

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