



R&D, firm size and innovation: an empirical analysis

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Abstract

Investment in R&D spawns innovations, which in turn, foster economic growth. In recent years, researchers have become increasingly aware of the role of industrial innovation in the rate of regional development and economic growth. In order to innovate, firms must invest in R&D (in-house or out-sourcing), and engage highly skilled labor that is able to cope with complex technological problems.

The plethora of empirical studies on the determinants influencing R&D expenditure, and thus the rate of innovation, suggests that this investment is related, in different degrees, to firm size, organizational structure, ownership type, industrial branch and location.

Large firms tend to invest more in R&D than do small ones. Numerous studies have found that R&D tends to be concentrated in large urban areas, and it plays a more vital role in creating innovation in central than in peripheral areas.

This paper presents a model whose assumption is that expenditure on R&D is influenced by a firm's characteristics—primarily its size, type of industrial branch, ownership type and location. The results obtained in the empirical analysis are based on data collected through personal interviews involving 209 industrial firms in the northern part of Israel.

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1. Introduction

There is ample empirical evidence supporting the hypothesis that R&D expenditures are a *sine-qua-non* for the firm's level of innovation activities (Stokey, 1995; Griliches, 1995; Bayoumi et al., 1999; Hall, 1996; Hall and van Reenen, 1999/2000; Shefer and Frenkel, 1998; Frenkel et al., 2001).

Ever since industrial innovation was recognized as a major force that fosters economic growth, there has been a flourishing interest in economic growth models with endogenous technological progress (Romer, 1986, 1990, 1994; Lucas, 1988; Dosi, 1988; Grossman and Helpman, 1990, 1991, 1994; Barro and Sala-i-Martin, 1995; Aghion and Howitt, 1998). The endogenous economic growth models assume that firms may invest in new technology through expenditure on R&D if they perceive an opportunity to make a profit. Thus, technological progress could explain the persistent growth in output, and consequently in income per capita or "standard of living" (Grosman and Helpman, 1991, 1994; Pack, 1994; Romer, 1994; Stokey, 1995).

Innovation provides new and, at times, unique opportunities for creating new firms and expanding old ones. Consequently, their market share is enlarged and, with increasing returns to scale, they enjoy greater production efficiency and a higher rate of economic growth (Schmookler, 1966; Segerstrom, 1991). Greater production efficiency enables industries to expand their domestic market share through import substitution, to increase local consumption and, at the same time, to penetrate new foreign markets and increase their export share (Porter, 1990; Krugman, 1979, 1991, 1995).

2. The determinants of R&D expenditures (The hypotheses)

Numerous studies have shown that R&D expenditures constitute the most influential variable in a firm's ability to innovate (Dosi, 1988; Freeman and Soete, 1997). Investment in R&D enables firms to hold a competitive edge over their competitors, at least during the first stage of the innovation diffusion process.

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2.1. Firm size

Previous studies have focused on the positive effect that firm size has on the level of R&D expenditure; that is, the firm's propensity to invest in R&D is positively associated with its size, *ceteris paribus* (see Fisher and Temin, 1973; Dosi, 1988; Acs and Audretsch, 1988, 1991a, 1991b).

It is widely believed that a major proportion of industrial R&D is undertaken by large firms. Therefore, it was assumed that economies of scale exist in expenditures on R&D. The relationship between firm size and R&D activities is particularly interesting in view of the fact that in recent years, we have encountered a large number of small firms that engage in innovative activity. This is particularly true of firms belonging to the high-tech industrial branch (Acs and Audretsch, 1993a; Kleinknecht, 1989, 1991; Scheirer, 1991). The current study will thoroughly investigate the degree of association between size of firms and rate of investment in R&D activities.

2.2. Location

The idea of paying attention to the specific location of firms with respect to innovation emanated from findings of previous studies in which firms' rate of innovation was seen to be location-specific. For example, high-tech firms located in metropolitan areas were found to be significantly more innovative than firms located in peripheral areas (Davelaar, 1991; Davelaar and Nijkamp, 1989; Feldman, 1994; Ciccone and Hall, 1996; Shefer and Frenkel, 1998; Audretsch, 1998; Audretsch and Feldman, 1996).

2.3. Innovation

A firm's decision to invest in R&D may be influenced by a number of factors, among which is the firm's current level of innovation. Although innovation is most often explained by the extent of in-house R&D efforts, as well as out-sourced R&D services, the existence of a causal relationship is conceivable—that is, firms will decide to increase their current level of R&D expenditures in consequence of their past success in generating innovations. Thus, we would expect to find a positive relationship between the level of investment in R&D and innovations (Acs and Audretsch, 1988, 1991a; Feldman, 1994; Audretsch, 1995; Kleinknecht, 1996; Freeman and Soete, 1997).

2.4. Export

High-tech industry is one of the leading export sectors. High-tech firms appear to be more export-oriented than low-tech or traditional firms. The fact that high-tech firms in Israel are export-oriented, is consistent with international trade theories of comparative advantage. In 1998, exports from the high-tech sectors accounted for about 37% of Israel's total industrial exports, whereas low-tech firms

exported only 8% of output. The importance of this export data is underlined by the relatively small size of the Israeli local market, and the consequent need for firms to develop export sales if they are to continue to grow. Thus, the need to export could account, in part, for the decision made by firms to invest in R&D in order to generate new innovation (Suarez-Villa and Fischer, 1995; Porter, 1990; Grossman and Helpman, 1990; Krugman, 1979, 1991, 1995).

2.5. Age of firm

Investment in R&D can be affected by firm size in different ways. Large firms are more likely to secure the funding needed for large scale R&D. By and large, large firms are older than smaller firms. Yet, it may be observed that in the high-tech industrial branch, we can find a large number of startups that are young and relatively small. These firms engage intensely in R&D activities. Thus, it will be interesting to investigate this hypothesis in the empirical analysis.

2.6. Firms that belong to a concern

Firms that are part of a concern are more likely to invest a larger amount in R&D than will individual firms. Here, too, it is assumed that a large concern is more able to secure the necessary funding for R&D. Thus, compared to individual firms, the risk involved is smaller for firms that are part of a concern (Frenkel et al., 2001).

2.7. High-tech vs. Traditional firms

Variations in the rate of investment in R&D may be associated with the industrial branch of the firms involved. Therefore, it would be appropriate to examine the impact of the industrial branch on the rate of expenditure on R&D. In order to do this, we decided to stratify the sample of firms into two basic industrial groups on the basis of their technological character. The first group, representing the high-tech industries, includes electronics, electro-optic and precision instruments. The second group represents the more traditional industries—plastics and metal products.

The reasons for this division are also connected to the relatively small number of plants affiliated with the metal products industry. The similarity in behavior between traditional industrial sectors (plastics and metal products), on one hand, and the difference between those industries and the high-tech industries, on the other, also lend justification to this grouping. Furthermore, numerous variations in innovative capability have been found to characterize these two industrial groups. The difference is reflected in the high expenditure on R&D made by the high-tech industries compared to the traditional industries (see Frenkel et al., 2001; Acs and Audretsch, 1993b).

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