Chapter 14

External Learning Opportunities and the Diffusion of Process Innovations to Small Firms: The Case of Programmable Automation

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14.1 Introduction

In this chapter, we are concerned with explaining which types of firms have failed to adopt well-known improvements in process technology. This problem has, of course, been the underlying concern of all studies of diffusion *"to rationalize why, if a new technology is superior, it is not taken up by all potential adopters"* (Stoneman, 1983). Drawing on various theoretical perspectives, we identify a number of different barriers to adoption. With data collected from a 1987 nationally representative sample of US establishments

N. Nakićenović et al. (eds.), *Diffusion of Technologies and Social Behavior*

in 21 metal-working and machinery manufacturing industries, we then construct a multivariate logistic regression model to empirically test for the effects of these factors on the likelihood of adoption of a particular process innovation, namely programmable automation (PA) machine tools.

A widely accepted tenet of contemporary analyses of the diffusion of innovations is that certain types of organizations are better positioned than others to generate and to adopt innovations (David, 1969 and 1975; Mansfield, 1968; Mansfield *et al.*, 1977; Nabseth and Ray, 1974; Stoneman, 1980; Utterback, 1988). With respect to process innovations in particular, economic research on technology diffusion has demonstrated the importance of differences, or *heterogeneity* in what Dosi (1989) has termed the *incentive structures* of firms to explain why some firms are quick to adopt a process innovation while others fail to do so. For example, some firms are price leaders in labor markets, willing to pay a premium in order to attract the best quality labor; other firms are willing to accept somewhat lower quality labor in order to keep their wages at or below the average paid by their competitors. Unless the expected labor savings from a new technology are greater than the capital costs of purchasing the equipment, a firm is apt to delay making that investment (Metcalfe, 1990; Salter, 1960). Thus, at any one point in time, high-wage firms are apt to have a greater incentive than low-wage firms to adopt a labor-saving technology. Moreover, there may be some minimum threshold scale (i.e., volume of output), below which the labor savings are too small for it to be profitable for the small firm to invest (David, 1975). In addition, there may be scale requirements that make it technically infeasible for small firms to adopt it. For example, Mansfield (1968) found that for certain innovations, there is a minimum scale at which a technology can be profitably used in particular industries. Hence, where the scale of investment necessary for a new process technology is very large, it can only be undertaken by large firms; small firms will simply lack the financial resources or size of revenue stream to make such an investment. From this body of research, we learn that the failure of small firms to adopt an innovation may be attributable to the heterogeneity of firms with respect to relative factor prices (of labor and technology), profitability, and the lumpiness of capital investment.

A second stream of research on the economics of innovation emphasizes differences in firms' technological and organizational competencies, which develop or accumulate over time (Cohen and Levinthal, 1990; Dosi, 1988; Freeman, 1988; Nelson and Winter, 1977 and 1982; Rosenberg, 1972 and 1982). In this line of inquiry, the problem of imperfect information for learning