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Modeling the adoption rates of manufacturing technology innovations by small US manufacturers: a longitudinal investigation

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Abstract

This study provides conclusive evidence to support the view that small plants are slower than larger plants to adopt manufacturing innovations. This empirical study based on over 1000 US manufacturing plants engaged in producing discrete products, studies the adoption of manufacturing technologies in small plants relative to large plants between 1993 and 1997.

Under the assumption that small manufacturers are disadvantaged, several federal and state programs have been created to assist small manufacturers in acquiring and adopting manufacturing innovations. Through quantification of technology adoption in small manufacturing firms, this study's findings reveal which manufacturing innovations are in greater need of governmental assistance programs. While small plants are making progress over time in catching up with larger plants in computerized technology use, they are not making similar progress in adopting manufacturing technology innovations in soft technologies. Several propositions for future research and recommendations for public policy are offered.

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1. Introduction

Small manufacturing firms are vital to the US economy. For example, over 70% of all manufacturing plants in the industries conforming to Standardized Industrial Classifications (SICs) 34–38 (a description of these industries in the Standardized Industrial Classification of the US Department of Commerce appears later) are small plants with less than 100 employees; there are over 30,000 such small plants in these industries (Bureau of Census, 1993). Yet,

small manufacturing firms, which are in a majority in this country, are at a disadvantage. Consider this:

Most of the literature on competitive strategy—from the fields of business strategy, marketing and industrial organization economics—has focused on the advantage of large firms and high market share: . . . (Fiegenbaum and Kirmani, 1991; p. 101).

Swamidass (2000a) found that more than 67% of US manufacturers report manufacturing cycle time reduction, manufacturing cost reduction, product line increase and ROI increase as a result of manufacturing technology use. Literature records that larger plants

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use more manufacturing technologies than small plants (Swamidass and Kotha, 1998; p. 31). The focus of this study is to estimate how much small plants lag behind larger plants in manufacturing technology use.

2. Research background

Since advanced manufacturing technology adoption is one form of innovative activity of the firm, let us consider the literature on the subject. The study of firm size upon innovative activity in the form of innovational effort and innovational success has a long history and has a classical tone to it (Schumpeter, 1934). One debate central to this issue surrounds the question, “Which is more innovative—the small firm or the larger one in regards to the use of new manufacturing technologies?” Let us consider the evidence in regards to manufacturing technology use.

First, in a study of JIT use (JIT is one of the soft technologies investigated in this study) among small as well as larger plants in the US, White et al. (1999) covered manufacturers, who are members of the Association for Manufacturing Excellence (AME). They compared small manufacturers (employment <250) to larger manufacturers (employment >1000). Using a sizable sample of 454 responses, they concluded that “JIT implementations are more common and more advanced in large US manufacturers than in small; . . .” (p. 1).

Second, Swamidass and Kotha (1998) studied the relationship between manufacturing technology use and size using survey and secondary data from 160 firms from industries covered by SIC 34–38 listed in the *Compustat* database (produced and marketed by the Standard and Poor’s Corporation, Englewood, CO). They studied the use of four groups of technologies and found that the use of the following three groups of technologies “increases with size” (p. 32).

1. Seven *information exchange and planning technologies*, which include LAN, computers used for factory control, computers for production planning, EDI, MRP and MRP II, and inter-company networks.

2. Five *automation technologies for high-volume production*, which include computer-aided quality control, computer-aided inspection, robots, and manufacturing-automation protocol.
3. Four *flexible automation technologies for low-volume production*, which include NC/CNC machines, programmable controllers, CAD/CAM, and FMC/FMS.

Swamidass and Kotha (1998) report that compared to other groups in the list above, *flexible automation technology in low-volume production* “grows faster . . . with increase in firm size. This may be due to the generally capital intensive nature of items such as FMS . . .” (p. 32). To date, Swamidass and Kotha (1998) provide the most robust findings concerning the increased use of a variety of technologies (16 in all) with size. Their study provides fairly strong evidence that larger manufacturers use more technologies and with greater sophistication.

Third, Acs and Audretsch (1990) found that the “relatively high cost of NC machines explains both their slow rate of diffusion as well as the bias in diffusion rates towards large firms” (p. 109).

Fourth, using Canadian firms, Globberman (1975) confirmed the findings of Mansfield et al. (1971) that the probability of adopting NC machines was positively related to firm size.

Finally, using samples of over 1000 plants, Swamidass (1996, 2000a) studied the use of 15 technologies (1996) and 17 technologies (2000a) and found that small plants used fewer manufacturing technologies in both instances. His explanation for this phenomenon is as follows.

- Small plants may need assistance to understand the use and benefits of new technologies.
- The training expense may hold back small plants from investing in manufacturing technologies.
- Funds for investment may be more difficult to obtain.

In summary, the foregoing illustrates the consistency of evidence that small plants do not use manufacturing technologies as much as larger plants, and do not use them with the same level of sophistication. Below is a tabulated summary of very recent studies comparing technology use in small and larger plants.

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