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A comparative study of advanced manufacturing technology and manufacturing infrastructure investments in Singapore and Sweden

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ABSTRACT

This empirical study compares the advanced manufacturing technology (AMT) investment, the manufacturing infrastructure investment, and the interaction effect between these two types of investments using data from a sample of firms in Singapore and Sweden. The results suggest that the interaction of AMT investment and manufacturing infrastructure investment has a positive impact on the firm profit and growth in Sweden, but does not have a positive impact on firm profit and growth in Singapore. In addition, this study shows that the AMT investment has significant positive correlation with infrastructure investment and firm performance in Sweden but not in Singapore.

1. Introduction

The phenomenon that the investment on advanced manufacturing technology (AMT) has been growing steadily in the past decades has led to several important research questions. For example, does the investment in AMT really pay off? How can firms make better use of the investment in AMT? Previous research that has studied AMT investment includes Waldeck (2007), Tan et al. (2006), Diaz et al. (2003, 2005), Laosirihongthong and Paul (2004), Machuca et al. (2004), MacDougall and Pike (2003), Das and Jayaram (2003), Kotha and Swamidass (2000), McDermott and Stock (1999), Sun et al. (1999), Swamidass and Kotha (1998), and Boyer et al. (1996). Boyer et al. (1997) show that, in US, balancing the AMT investment and the manufacturing infrastructure investment results in better firm performance such as profit and growth. In this paper, we compare the AMT investment and manufacturing infrastructure investment in Singapore and Sweden in order to see whether the effect of AMT investment and manufacturing infrastructure investment follows the same pattern as that in US.

There are several reasons for this comparative study. First, because Sweden and Singapore have quite different business environments, the relative importance of AMT investment and manufacturing infrastructure investment might be different. While Sweden is a developed Western European country, Singapore is a newly industrialized Asian country. The investment in AMT and manufacturing infrastructure played a significant role in Singapore's high level of economic growth and enhanced its position as a manufacturing leader in the Pacific rim (Zhao and Co, 1997; Ward et al., 1995). Second, there are several compelling reasons to suspect that the use of AMT might differ between developed countries and newly industrialized countries (Zhao and Co, 1997). One reason is that companies may face different challenges during the implementation of AMT in developed countries and newly

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industrialized countries. Another reason is that lower labor costs in the newly industrialized countries might make the economic justification of AMT implementation more difficult.

This study contributes to both the academic literature and industry practice. This study enhances the AMT research stream by testing the generality of the findings in Boyer et al. (1997). Since the discovery of the interaction effect between AMT investment and manufacturing infrastructure investment in United States (Boyer et al., 1997), no research has studied this relationship in other countries. While theory building is important to our field, there appears to be a lack of theory-testing studies. One of the few recent theory-testing studies in operations management is the research by Frohlich and Dixon (2001), which convincingly argue the necessity of testing existing theories. This study seeks to fill a gap in the literature by providing an empirical test of the relationship among AMT investment, manufacturing infrastructure investment, and firm performance across different countries.

From a managerial view point, understanding the relative importance of AMT investment and manufacturing infrastructure investment on firm profit and growth is important for maximizing the investment returns because all companies have limited resources. As such this study hopes to build on the findings of Boyer et al. (1997) and Jonsson (2000) and provide additional insights on the implementation of AMT in developed as well as newly developed countries. As Sutton and Staw (1995) point out, "Empirical evidence plays an important role in confirming, revising, or discrediting existing theory and in guiding the development of new theory" (page 373). We expect that this study will add generality to several findings in Boyer et al. (1997) and as such make a contribution to theory.

The remainder of this paper is organized as follows. Section 2 reviews the literature of AMT, manufacturing infrastructure, and firm performance. In Section 3 we develop the research hypotheses. The research methodology is presented in Section 4. Section 5 provides the analysis results. We discuss the research results in Section 6 and conclude the paper in Section 7.

2. Literature review

In this section, we review the literature of AMTs, manufacturing infrastructure, and firm performance.

2.1. Advanced manufacturing technology

AMT is defined as an umbrella term to describe a variety of technologies that utilize the computers in the manufacturing activities either directly or indirectly (Boyer et al., 1996). Examples of such technologies are computer-aided design, computer aided manufacturing, computer-aided engineering, and manufacturing resource planning. Non-computer related technologies might also be considered as AMT technologies if they complement the usage of other AMT technologies.

Previous studies have categorized AMT in several ways. Adler (1988) and Boyer et al. (1996, 1997) categorize AMT into three classes: design AMT, manufacturing AMT, and administrative AMT. Kotha and Swamidass (2000) and Swamidass and Kotha (1998) group AMT into four dimensions: information exchange and planning technology, product design technology, low-volume flexible automation technology, and high-volume automation technology. In this research, the three measurement scales used are similar to the three categories of design, manufacturing, and administrative AMTs in Boyer et al. (1997). Design AMTs include computer-aided design and computer aided engineering. The focus is on product and process design. Manufacturing AMTs refer to computer-controlled processes in the fabrication/assembly industries, automatic material handling, automatic storage, and retrieval systems. The measurements used in this study include computerized numerical control, computer-aided manufacturing, robotics, real-time process control system, flexible manufacturing systems, automated material handling system, environment control system, and bar coding/automatic identification. The focus is on actual production of the products. Administrative AMTs include computerized shop-floor tracking systems. The measurements used in this study comprise manufacturing resource planning, activity-based accounting systems, electronic mail, electronic data exchange, and office automation. The focus is on facilitating and monitoring operations. The survey questions and descriptive statistics for each AMT measurement item are presented in Table 1.

AMTs provide a variety of operational benefits which include better coordination between different departments, greater control of the processes, reduced product design time, shorter lead time, and stable high quality outputs (Boyer et al., 1997; Small and Yasin, 1997; Sun et al., 1999). Previous studies have also considered the impact of AMTs on firm level performance such as profit and growth (Kotha and Swamidass, 2000; Jonsson, 2000; Swamidass and Kotha, 1998; Boyer et al., 1997). However, there is no clear relationship between AMT investments and firm performance. While most studies suggest that the investment in AMTs could lead to improved firm performance (Small and Yasin, 1997; Sun et al., 1999; Small, 1999; Co et al., 1998; Udo and Ehie, 1996; Kakati, 1997), few studies find that AMT investment alone is not significantly correlated to firm performance, especially tangible financial performance (Kotha and Swamidass, 2000; Swamidass and Kotha, 1998). Swamidass and Kotha (1998), for example, conclude that "AMT use does not show any direct impact on firm performance". Kotha and Swamidass (2000) suggest that there is likely a fit between AMT investment and business strategy. In their study, profitable firms emphasizing a cost-leadership approach were indifferent to the level of AMT investments. They also show that firms showing superior growth emphasized AMT investments more than firms showing superior profit. Other studies have, however, shown a greater impact of AMT on profit than growth (e.g., Boyer et al., 1997). Boyer et al. (1997) suggest the importance of other factors such as manufacturing