

## Chapter 14

# Developments in Manufacturing Technology and Economic Evaluation Models

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This paper describes recent developments in technologies for automated, integrated manufacturing and theoretical models for the economic evaluation of those technologies. This chapter attempts to be broad and serve several purposes: (1) to provide an introduction to technologies for manufacturing automation, (2) to discuss the managerial challenges to adopting those technologies, (3) to provide conceptual underpinnings for considering economic evaluation of manufacturing technology investments, and (4) to review the literature on theoretical models of economic evaluation of manufacturing technology and develop a framework for that literature.

### 1. Introduction

Driven by international competition and aided by application of computer technology, manufacturing firms persistently pursued two principal trajectories during the 1980s: automation and integration. Automation is the substitution of machine for human function; integration is the reduction of buffers between physical or organizational entities. With the aims of reducing their needs for low-skilled labor and liberating human resources for knowledge work, firms have automated away simple, repetitive, or unpleasant functions in their offices, factories, and laboratories. To improve quality, cost, and responsiveness to their customers, firms are reducing the physical, temporal, and organizational buffers between productive entities in their operations. Such buffer reduction has been implemented by the elimination of waste, the substitution of information for inventory, the insertion of computer technology, or some combination of these.

In most process industries, automation and integration have been critical trends for decades. However, in discrete goods manufacture in most of the Western world, significant movement in these directions is a recent phenomenon. In many cases, factory automation and integration require significant capital outlays. Therefore, the advent of new computerized manufacturing

technology for automation and integration has also spawned a flurry of scholarly research into the development of models for economic evaluation of investment opportunities in these technologies.

The goal of this chapter is to examine the contributions of the model-based theoretical work from management science and operations research (and to some extent, economics) for use in evaluation of technology investments to support automation and integration. Toward that end, Section 2 begins by describing in some detail the trends toward automation and integration in manufacturing as well as the technological hardware and software that has been evolving to support and accelerate these trends. Section 3 discusses a number of management challenges and opportunities created by these technologies, ranging from the adjustments required by the human resource system in response to significant technological change, to the economic evaluation of these technologies. Section 4 provides a broad framework for the technology evaluation problem and a brief discussion of manufacturing performance evaluation models and their relationship to the economic evaluation literature. Section 5 provides some historical perspective on relevant literature from the field of economics, and then surveys recent modeling work on economic evaluation models for technology adoption. Most of the modeling work done on technology evaluation that is surveyed in this section seems to have been driven by two of the effects of investment in the new technologies described in Section 2: (1) the increased flexibility provided by these systems, and (2) the increased capital intensiveness and the resulting change in the firm's cost structure arising from the new investments. Section 7 briefly describes some related empirical work. Section 7 discusses the usefulness of the modeling literature for the economic evaluation of new manufacturing technology and presents a research agenda for the area.

## **2. A description of the new manufacturing technologies**

This section describes the technology that is supporting automation and integration in manufacturing. Some of this technology, such as Computer-Aided Design (CAD) and robotics, is reasonably well established and productively employed in many locations. Other technologies, Computer-Integrated Manufacturing (CIM), for example, are still primarily in the future plans of most firms. Despite these differences, all of the technologies described below are expected to play important roles in international competitiveness in the coming decade.

### *2.1. Automation in manufacturing*

As characterized, for example, by Toshiba [1986], automation in manufacturing can be divided into three categories: factory automation, engineering automation, and planning and control automation. Automation in these three