Abstract

Unless procedures for the economic evaluation of flexible manufacturing technology are revamped, much of U.S. industry could repeat the experience of American automobile and steel companies from the recent past. The dynamic character of flexible manufacturing technology in terms of associated developments in microelectronics, a trend toward equipment modularity, and the increasing diversity of relevant markets make flexible manufacturing especially vulnerable to the weaknesses of conventional procedures for the justification of capital expenditures. Building on the work of V. Smith, M.I. Kamien and N.L. Schwartz, this paper presents optimization models from which economically reasonable plans can be derived for the implementation of flexible manufacturing technology. Although the assumptions of these models are not focused on the situation of a specific plant, model implications and the overall perspectives here on the economic evaluation of flexible system options should provide general guidance for manufacturing planners.

Keywords and phrases

Facilities equipment planning, capacity expansion, replacement, investment.

1. Introduction

Traditional approaches to the economic introduction of new manufacturing technology tend to discourage its adoption according to such authors as Gold and Boylan [4]. Among the issues inadequately addressed by traditional approaches are the following: (i) the challenge to or opportunities for installed equipment not only from current best-practice technology but also from anticipated best-practice tech-
nology; (ii) the dependence of the feasible set of future options on current choices; and (iii) determination of effective demand by the intersection of manufacturing technology and market characteristics. The dynamic nature of current markets and the technology for flexible manufacturing systems (FMSs) makes imperative a new economic evaluation approach.

The rate of innovation in microelectronics with concommitant development in programmable automation is one major basis for the dynamic nature of FMSs. Lending itself to incremental implementation, the modular character of FMSs provides another technology-driven dynamic. Closely related to these technological dynamics, rapidly changing demand tends to be an important justification for FMSs. Such change takes many forms [3], including the composition of the product set, proportion of overall output for any product within such a set, the level of overall output, the required set of operation sequences, and the diversity within a given type of unit operation. Conceptually, some of this variety can be managed through group technology and the notion of substitute products as belonging to a portfolio of product life cycles.

Aside from the dynamics of FMS technology and of the product portfolio, the industrial environment for FMS implementation is characterized by strong inter-firm rivalry. The manufacturers of professional microcomputers such as IBM, Digital Equipment Corporation, and Hewlett-Packard illustrates this phenomenon. Apropos of many high technology industries, the competitive concerns in the manufacture of professional microcomputers are both domestic and international [2].

2. Literature review

Expenditures for new manufacturing technology have typically been rationalized in a replacement framework, especially under stationary demand, or in a capacity-planning framework under non-stationary demand. The replacement procedure by Terborgh [9] required the firm to retire old equipment and simultaneously introduce current best-practice technology when the cost of extending the life of the old equipment by a year first equalled or exceeded the annuitized cost of the new equipment over its economic life. This approach comprehended neither the possibility of introducing new technology before retiring the installed equipment, nor the potential for greater quantity demand as a result of the more favorable cost characteristics of the new technology. This potential was first rigorously identified by Smith [6], who demonstrated the inseparability of replacement decisions and capacity planning under technological change in manufacturing processes. However, the option of introducing current best-practice technology prior to or entirely without retiring old equipment was originally established as possibly profitable by Kamien and Schwartz [5].

Their model addresses a two-stage equipment replacement decision where technological advance is perfectly anticipated. The life of the firm is divided into two