CAPITAL BUDGETING AND OPTIMAL TIMING OF INVESTMENTS IN FLEXIBLE MANUFACTURING SYSTEMS

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Abstract

This paper investigates the financial-economic decision process for investments in flexible manufacturing systems (FMS). Contrary to popular belief, we show that conventional capital budgeting techniques can be used to make such investment decisions. First, we identify the overall impact of installing an FMS and present guidelines for a cash flow forecasting model. We then present ways in which to incorporate uncertainty in these cash flows within a risk-adjusted discount rate. These expected cash flows and the discount rate are used in calculating the net present value (NPV). Once the capital budgeting analysis is completed, a critical issue facing the firm is the optimal timing of the installation. We reinterpret the general results on optimal timing of investments within the special context of an FMS project. Finally, we illustrate the above technique via a stylized example.

Keywords and phrases

Capital budgeting for FMS, optimal timing of investments, overall impact of FMS.

Introduction

Manufacturing industries in the U.S. and in other developed nations are rapidly increasing the use of flexible manufacturing systems (FMS) in mid-volume, mid-variety production applications. This macro phenomenon is driven by firm level decisions to replace existing conventional plant and equipment with FMSs and other advanced technologies. Although much attention has been devoted to the engineering feasibility and production management aspects of FMSs, very little has been focused on the financial and economic considerations. Nevertheless, a firm's decision to invest in an FMS remains an economic issue.

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The aims of this paper are twofold: (i) to modify the capital budgeting framework by incorporating special characteristics of the FMS, and (ii) to apply recent results in the financial economics literature to obtain the optimal time to invest in an FMS. Several previous papers in the industrial engineering literature have investigated the economic implications of advanced automation. Notable among these is the MAPI method and its variants which uses engineering data in evaluating the economic feasibility of manufacturing projects.* More recent studies by Boothroyd [3] and Hutchinson and Holland [4] have remained within the engineering costing framework in their more sophisticated economic analysis of advanced manufacturing systems.

All of this analysis fails to bring to bear important new developments in microeconomics and modern finance theory in analyzing the radically modified risk characteristics of FMSs. The industrial engineering literature is prevalent with the misconception that FMSs can not be evaluated using conventional capital budgeting methods such as the net present value (NPV) method. The basic argument in these studies stems from the fact that the introduction of an FMS in one point of a production process has far-reaching ramifications throughout the plant. It is true that in such cases a local cash flow analysis will give misleading results. In two recent studies, Kulatilaka [6,7] demonstrates how, with appropriate modifications, an overall NPV analysis will be suitable for evaluating FMS projects. In the present paper we further develop the above approach and apply it specifically to FMSs.

Perhaps the most important contribution of this paper is the treatment of the optimal investment timing problem. We follow theoretical developments by McDonald and Siegel [9] and cast the timing of FMS installations as an option to postpone. We use a stylized example to study the value of this option under various scenarios.

The rest of this paper is organized as follows: In the next section we identify the costs and benefits from an FMS and provide the basic guidelines of a forecasting model which will translate the non-pecuniary effects into cash flow equivalents. Section 2 provides a risk analysis of the estimated cash flows. Section 3 makes a brief statement of the capital budgeting decision criterion based on the NPV. A justification of the NPV method is presented in an appendix which also provides a tutorial on different capital budgeting techniques. Section 4 provides a discussion of the investment timing issues. In sect. 5 we present a stylized example to illustrate the techniques discussed in this paper. Finally, we make some concluding remarks.

1. Cash flow forecasting

The first step in any investment analysis is to identify and estimate the various present and future cash flows resulting from the proposed project. The difficulty of

*Footnotes numbered 1 - 17 are listed at the end of the paper, preceding the references.