ON AN ECONOMIC MEASURE OF SUPER-FLEXIBILITY 
IN AN UNCERTAIN ENVIRONMENT

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ABSTRACT

A probabilistic economic measure is suggested to assist in the evaluation of the flexibility of Flexible Manufacturing Systems (FMS's). After deriving its analytical properties, the manner in which this measure could assist the decision-maker in the FMS project selection problem is shown. The measure determines the willingness of a risk-neutral decision maker to pay for a so-called "super flexible" joint technology, and considers the flexibilities of both manufacturing systems being evaluated instead of just merely selecting the better of the two. The measure finds a maximum price that a risk-neutral decision maker would pay, given that the economic value of a manufacturing system is evaluated via a stochastic one-period model.

The analysis of the statistical properties of the measure is based on the evaluation of the value of information for a risk-neutral decision maker facing a project-selection problem. There are several advantages to using the proposed measure. First of all, it is evaluated in monetary terms. Secondly, an upper bound on the maximum price that a risk-neutral decision-maker would pay can be provided based on very limited information about the underlying distributions that describe the economic values of each manufacturing system. Thirdly, it may guide the decision-maker to look at possible marginal improvements of flexibility through a technological change. The limitations of the suggested measure are also discussed, with particular reference to future research focused on the important engineering implications of the approach suggested here.
1. INTRODUCTION

Increasingly, as flexible manufacturing technologies become available across a broad range of applications (see for example Jaikumar, 1986), more and more firms must make decisions about the adoption of Flexible Manufacturing Systems (FMS's). So far, few theoretical and empirical economic justifications for FMS's have been discussed in the literature (see Snader, 1986; Canada, 1986) concerning the savings attributable to FMS's. These inadequacies seem due in part to the difficulties of explicitly quantifying the benefits from investment in "flexibility."

In general terms, "flexibility" is viewed as the ability of a system or decision-making process to effectively respond to change. This concept has been examined by several authors spanning several disciplines (Cunningham and Mandelbaum, 1985; Rosenhead and Gupta, 1968; Harrigan, 1985; Merkhofer, 1977; Marshak and Nelson, 1986; Pye, 1978; Rosenhead, et al., 1972; Brill and Mandelbaum, 1989; Mandelbaum and Buzacott, 1986).

The need for a common treatment has recently become more pressing as the strategic advantages of manufacturing flexibility have focused managerial attention on FMS (Hayes, Wheelwright and Clark, 1988). This subject is drawing research attention from several disciplines. For example, Stecke, et al. (1985) discuss machining flexibility and assembly system flexibility; Buzacott (1982) discusses action flexibility, state flexibility, job flexibility and machine flexibility; Zelenovic (1982) addresses strategic planning flexibility, design flexibility and adaptation flexibility; and Yao (1985) focuses on routing flexibility. Kumar (1986) also recognizes that there can be loading flexibility, material handling flexibility, information flow flexibility and so on.

In what follows, we review the literature in terms of current approaches and problems to be addressed in the measurement of flexibility. Next, we provide some motivation for the proposed economic measure, including an illustrative example. Finally, the measure, along with an analysis of its properties and possible applications, is described.