

# Equipment flexibility vs. inventory: A simulation study of manufacturing systems

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Received 6 January 1999; accepted 12 April 2000

## Abstract

Technological flexibility requires very high initial investments and therefore a decision to acquire it is both risky and strategic in nature. The objective of this paper is to find out the technological flexibility requirements in just-in-time manufacturing under different environmental situations. The simulation results show that the incorporation of flexibility in a manufacturing system is vital. The choice of the extent of flexibility is driven by the market and economic factors. © 2001 Elsevier Science B.V. All rights reserved.

*Keywords:* Manufacturing strategy; Just-in-time; Flexibility; Simulation

## 1. Introduction

In recent years, just-in-time (JIT) production system has drawn considerable attention and proved to be extremely successful, especially in Japan. JIT is a philosophy of eliminating waste in the total manufacturing process – from procurement of raw materials to distribution of final products or services. This makes the manufacturing process more streamlined, cost efficient, quality oriented and responsive to the customer. JIT thus acts as a strategic weapon in a competitive business environment. JIT improves the system design to help manufacturing organizations operate more efficiently by reducing their inventories.

In the present environment characterized by uncertainty, greater customer expectations, competition, and fast developments in technology and products, traditional methods of manufacturing planning and control based on the push system are no longer economical. Inventory under these approaches is pushed through the work stations based on some predetermined plan. One of the weaknesses of the push system is that an error in demand estimation results in large inventories, delayed shipments, long throughput times and shortages. In contrast, the JIT manufacturing system emphasizes production or procurement of parts only when these are needed. Such systems would, however, necessitate flexibility of equipment, multiskilled workers and reliable sources of supply.

Flexibility is the ability of a manufacturing system to cope with changes in the nature, mix, volume or timing of its activities. Flexibility in

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a manufacturing system ensures that the production rate can be matched with demand, leading to savings in inventory-related costs, reduced lead times and increased quality.

Flexibility is not free, it comes at a cost. Flexibility more often means extra capacity either in the form of extra machines, technology or in manpower. For developing economies, where the cost of capital is high, the decision to acquire a flexible manufacturing system may not be economically justified, whereas for Japan and other capital rich countries it may be the ideal thing to do. The nature of industry also influences the relative importance of inventory control. For a highly capital intensive factory, machine utilization may be more important than inventory reduction. In a steel wire manufacturing company, a year of inventory may be insignificant as compared to one investment decision on the acquisition of a capital asset. On the other hand, in an automobile assembly, the raw materials are high value added items and the inventories are indeed a major cost component.

Thus JIT is not feasible in developing countries and traditional just-in case (JIC) has its own demerits. JIC tends to cover up problems existing in the factory. JIC systems are push systems in which control policy gives a production trigger based on forecasted demand and predicted product flow in the production and inventory system. Under these policies inventory is considered as an asset. It protects against forecast error, machine problems and late vendor deliveries.

Non-feasibility of JIT and demerits of JIC lead to an interesting research poser, namely, to determine the best mix of JIT and JIC for these conditions. Certain external and internal factors decide the design of the mix of JIT and JIC for formation of a 'JIT like' manufacturing system which is economical to operate and meets competition.

The intent in this paper is to investigate the effects of technological flexibility to find out the extent of flexibility required in an environment characterized by different levels of variability. By creating the choice set and evaluating the alternatives on economic criteria, the study suggests how to actually achieve such flexibility. This results in the development of 'JIT-like' manufacturing system to meet the challenges of competition.

## 2. Literature review

JIT manufacturing has been an area of extensive research in recent years. The benefits of JIT implementation have been acknowledged by many researchers [1–5]. A large variety of approaches have been adopted for the study of JIT systems. Simulation has been widely used as a vehicle to identify and study the internal and external factors that affect the success of pull system in JIT, to determine the number of kanbans required at each work station and to investigate the effect of demand and processing time variability [6–10]. Several researchers [11–14] studied kanban and MRP systems to develop hybrid systems for variable and uncertain manufacturing conditions. Huang et al. [15] and Kimura and Tareda [16] analyzed the pull system for multi-line, multi-stage production systems.

Flexibility of manufacturing systems is an important dimension for the successful operations of the pull system. Flexibility is defined by Gupta and Goyal [17] and Gupta and Gupta [18] as the ability of a manufacturing system to cope with changing circumstances and instability caused by the environment. Gerwin [19] gave mix, changeover, rerouting and volume flexibility as the dimensions of flexibility related to market-oriented uncertainties. Wildemann [20] observed that it is more profitable to store capacity in capital assets, rather than in liquid assets. Atwater and Chakravorty [21] took a very strong stance on the necessity of protective capacity. They asserted that the balanced plant is not only impossible to attain but also undesirable. Nandkeyolar and Christy [22] observed that as the product diversity increases, for a given system there is a level of flexibility that will optimize system performance. Fine and Freund [23] illustrated that when the demand is negatively correlated between two products, greater risk stimulates the need for flexible manufacturing technology. Benjafaar [24] observed that flexibility is the mechanism in dealing with the disruptive potential of the variability in a dynamic environment. Porteus [25] studied the tradeoff associated with reducing the set-up costs in the classical EOQ model and found that investing in reduced set-up is economical merely on the basis of reduced inventory-related costs.

Studies over the years have established the benefits of the flexibility element of the JIT approach.

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