Information technology has enabled substantial automation of manufacturing functions by way of computer integrated manufacturing and flexible manufacturing systems. These systems offer many benefits but also require substantial long term capital investment. Traditional cost accounting and capital budgeting techniques fail to fully justify installation of these systems. A substantial quantity of literature in this field is reviewed to come up with the existing state of affairs in manufacturing automation and economic justification of flexible manufacturing systems. Economic justification of flexible manufacturing systems on broader basis than provided by traditional methods appears to be not only desirable but also imperative for manufacturing firms going in for them. Based on literature review, some guidelines have been culled for managers to enable them to invest in these systems on a more rational basis and with more confidence. A bibliography of articles and research papers provides further references and readings to practitioners in this area.

In the beginning of this century, manufacturing was revolutionized with the introduction of “transfer line” technology for mass production where, basic inputs are processed in a fixed sequence of steps using equipment specifically designed to produce a single standardized product in extremely large quantities for extended periods of time. In the late twentieth century, there is again a revolution in manufacturing. The specialized, single-purpose equipment that characterized transfer lines is being replaced by flexible machine tools and programmable, multi-task production equipment. These systems provide a wide range of benefits including great improvements in quality, customization of products, extremely high output efficiencies of production in very small batches, etc. At the same time, these systems are expensive and require a commitment of sizable funds for a long time to implement them. The question of economic justification of these systems assumes importance in this context.

Flexible Manufacturing System (FMS) is an integrated system of machine tools and material-handling equipment designed to manufacture a variety of parts at low or medium volumes. It can also be viewed as an integrated system for automatic random processing of work units through various workstations in the system. FMS actually is an umbrella term, which in turn refers to flexible assembly, fabrication, machine and welding systems. An FMS is characterized by its ability to process many variations within a single-product family as well as ability to make rapid extensions of an existing product line.

There are many motivations for adopting FMS. These are:

- Cost Reasons
- Lower inventory levels
- Reduced labor costs
- Reduced scrap and rework
- Reduced floor space requirements
- Reduced information tracking costs
- Time Reasons
- Sizable reductions in production-cycle times due to:
  - The ability to route around bottlenecks and machine
breakdowns
• Lower setup times
• Reduction in fixture and tooling errors
• Reduced human intervention in all phases of manufacturing

• Marketing Reasons
• Shorter delivery times
• Ability to maintain production of low-volume products
• Ability to make rapid changes in product mix and volume to accommodate market shifts
• Quicker introduction of new and modified products
• Quality Reasons
• Very high first-time-through quality levels
• Maintain high consistency levels with which parts are processed
• Technology Reasons
• Creates or maintains a competitive advantage
• Desire to experiment with new technology
• Desire to be on the technology frontier

Different firms acquire FMS for different reasons. Usually, a common reason is competition from other firms. With increased customization of products, the firms which can deliver the desired product to customers at the right time, in the right quantity and at the right price turn out to be winners. Time, quality and meeting customer requirements are the main reasons for adopting FMS.

There are a number of positive consequences as also a few negative consequences associated with adopting FMS. Based on a survey of twenty US firms (Forster and Horngren, 1988.), these consequences are:

• Positive consequences of adopting FMS:
• Reductions in direct labor ranging from 50 percent to 88 percent;
• Increase in machinery efficiency ranging from 15 percent to 90 percent;
• Reductions in production-cycle time ranging from 30 percent to 90 percent and;
• Reductions in floor space ranging from 30 percent to 80 percent

A survey of thirty UK engineering companies reported the following (Forster and Horngren, 1988):

• Mean reduction in work in process of 68 percent; and
• Mean increase in machine use from 40-50 percent with conventional machine tools to over 90 percent with FMS.

Other benefits of adopting FMS are:
• The ability to produce a wide variety of products in a wide range of volumes.
• The ability to respond quickly to customer demands and product design changes.

• The ease of adding new members to a product line and accommodating a change in volume in existing products.
• Vastly improved product quality; almost zero defect in some cases.
• Less setup time because of better computer scheduling and setups performed at the load/unload station instead of at each machine.
• Better information on production, system utilization, tooling, maintenance and the like.
• Negative consequences of adopting FMS.

Four main classes of negative experiences have been reported:

• Cost related. This class includes dramatic underestimation of the cost of installing the FMS, not being able to eliminate the labor time predicted in the proposal, and not achieving the planned machine use.
• Time related. Long delays in making the FMS operational have been reported by several firms.
• Technology related. This class includes breakdowns in hardware (e.g. automated guided vehicles, machines, and tools) or software (e.g. tool record programs and system supervisory programs).
• Labor related. Problems with labor unions have been reported at many firms.

Usually protracted negotiations over labor issues delay the implementation of FMS. Because of so many benefits of having FMS, a number of firms have adopted and are in the process of adopting them. As reported by Ranta and Tchijov (1990), FMS can be divided into two categories: compact systems costing less than US $4 million and high-efficiency systems costing more than US $5 million. A typical compact system consists of 2-4 CNC-tool or machining centers, conveyor and automatic storage and retrieval systems and two robots for material handling and a programmable controller for systems control. A typical large scale system consists of 15-30 CNC-tools, automated guided vehicles and an automated storage and retrieval system for material handling, a local area network and distributed microcomputer based cell and machine control systems and usually two VAX-type computers for coordination, scheduling and database management. It usually has a backup computer system and a software system for the coordination of the systems. According to this study in spring 1989 there were around 1200 flexible systems worldwide and at least a 15% annual growth rate of FMS population is predicted for the rest of this century. The number of implemented FMS and estimated numbers in future is given in Table 1.

Based on 293 documented cases, Table 2 shows the FMS distribution over investment (Ranta and Tchijov, 1990).

In 1985, there were approximately 50 fully computerized FMS installations in the United States. By 1990, close to 300 complete FMS installations were expected to be operative. In
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