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Production Management for Small- and Medium-Scale Furniture Manufacturers

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

General Studies Series

PRODUCTION MANAGEMENT FOR SMALL- AND MEDIUM-SCALE FURNITURE MANUFACTURERS

A MANUAL FOR DEVELOPING COUNTRIES

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 1992

Note

This publication previously appeared as "Production management for small- and medium-scale furniture manufacturing firms in developing countries" under the symbol ID/300.

ID/SER.O/3

UNIDO PUBLICATION
UNIDO.92.3.E
ISBN 92-1-106258-6

PREFACE

This manual has been written in response to the growing need for "software" information (how to manage a particular technology) on the part of small- and medium-scale furniture manufacturers in developing countries. Such information, when it is available, is often of the "bits and pieces" variety; it seldom offers an integrated perspective. On the other hand, a considerable amount of "hardware" information (what machines are best suited for various applications) is available, distributed by suppliers of machinery and general furniture manufacturing technology. Both types of information, however, are required for the effective diffusion of modern furniture manufacturing know-how in developing countries, especially to small- and medium-scale firms. Success in the development of the principles, concepts, tools and practices needed for the smooth and effective operation of such firms lies in the selection, adaptation and application of existing production management principles.

This manual has been prepared primarily for owner-managers; production managers; and industrial extension officers or small-business consultants. For brevity, the term "small-scale" is used throughout the publication to denote a firm employing up to 100 workers, i.e. a family, small or medium-sized business. It is assumed that such a firm will be managed by one person (owner-manager) or a group of partners, and have a highly fluid organizational structure with few staff support functions. Furniture manufacturing refers to the production of pieces for household, office and institutional use.

The manual contains eight chapters, all of which deal with production management themes that are seldom given adequate coverage in the literature on furniture manufacturing. Topics covered range from the production function to production planning and control, which is considered by many to be the integrating element of the production system. Topics such as the principles of plant organization, safety, accident prevention, and maintenance management are well covered in contemporary, readily obtainable publications on production management, and for that reason have not been included in the present manual. The reference works consulted in the preparation of the manual are listed in the form of a bibliography.

The manual was prepared for the United Nations Industrial Development Organization (UNIDO) by Eduardo Q. Canela (Philippines), a production management consultant for small- and medium-scale manufacturing enterprises in developing countries. The views and opinions expressed are those of the author and do not necessarily reflect the views of the UNIDO secretariat.

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Introduction

Furniture manufacturing firms, irrespective of their size or the diversity of their product lines, have two basic functions: (a) they produce furniture pieces and (b) they endeavour to market them. The performance of these functions entails labour and money, which explains the organization of the large-scale enterprise in terms of marketing, production, finance and personnel management. In smaller firms, however, the various responsibilities of management may not be as neatly categorized, as most of them are normally assumed by the owner-manager. In the developing countries, especially, most small-scale furniture manufacturing firms have either a single proprietor or are family-owned.

Some management experts believe that the lack of precisely defined management functions is a distinct advantage for the smaller firm, but the majority argue that separating those functions enhances a firm's potential for growth and survival. They also argue that the blurring of managerial responsibilities is responsible for a host of problems unique to the smaller firms, beside those normally encountered in production management.

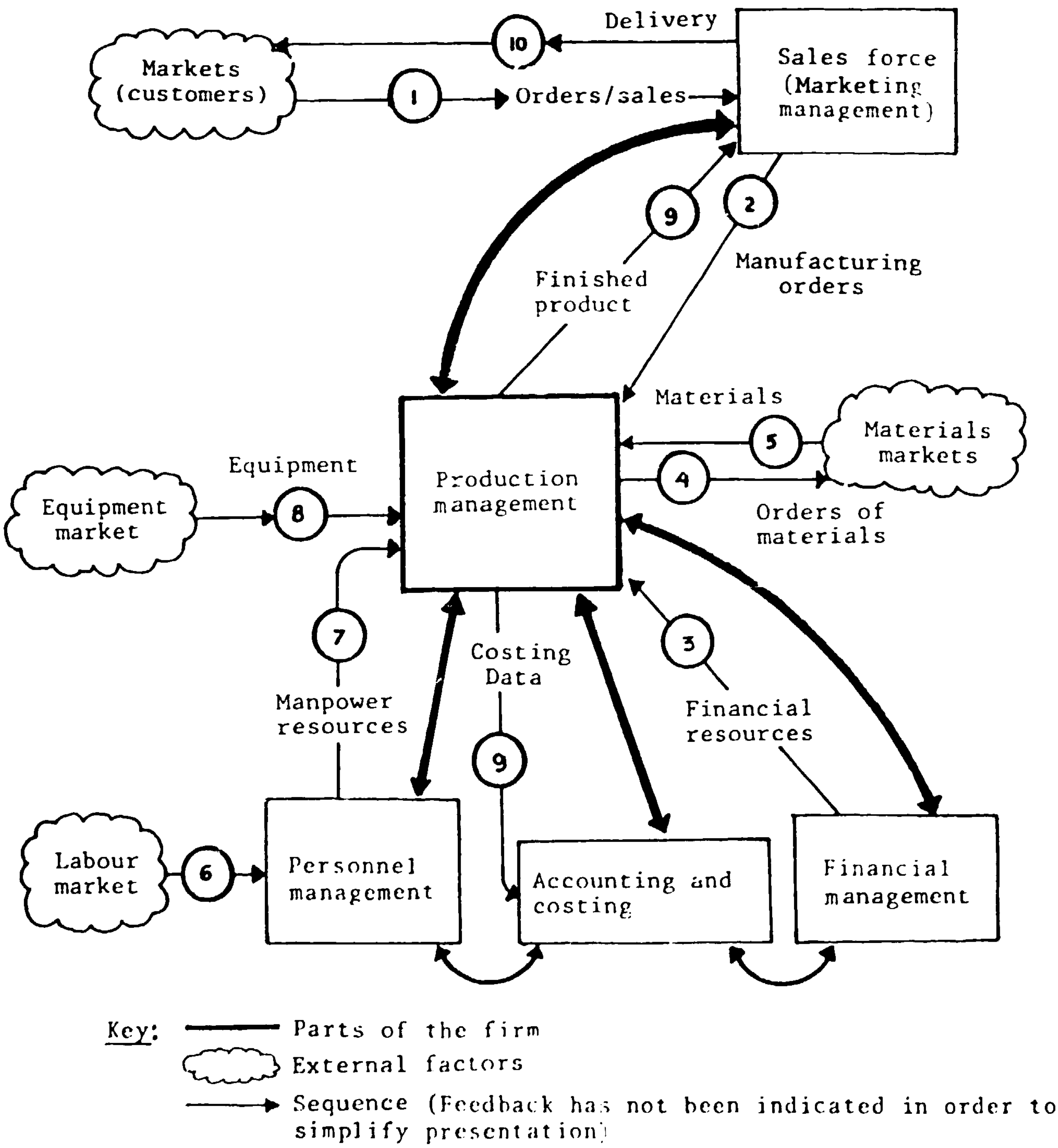
Production management: definition and scope

Production is to the manufacturing enterprise what the engine is to the automobile: it keeps it in constant motion with the primary objective of delivering convenience and comfort to customers through its products. Production management refers to those activities involving planning, organizing, directing, integrating, controlling and evaluating the entire process of manufacturing goods or providing services at the right cost and in the right time, quantity, quality and place. It is closely related to other functional areas of the manufacturing operation. This relationship, greatly simplified, is illustrated in figure 1.

It will be observed that production is closely connected with all other functional areas of manufacturing and must not be treated as an independent or isolated activity. The simple relationships depicted in the figure in reality represent the flow or deployment of information, money, material and personnel within the firm. The organizational structure of the furniture manufacturing enterprise, whether simple or complex, must represent a constant attempt to orchestrate or integrate all the production-related activities of the various functional areas with a view to ensuring attainment of the goals of the enterprise. Figure 1 may also be used as a starting point in determining the importance of, and relationship between, the various functional areas of the manufacturing operation, although such determination may lead to a certain amount of conflict. The perennial conflict between production and marketing staff as to which side dictates what the firm should produce or sell is a familiar one. It may not occur when both the production and marketing functions are subject to direct management. Subsequent growth and expansion, however, may necessitate their separation, in which case the conflict becomes almost inevitable. Generally speaking, when a firm, has reached the growth

* For the notes, see p. 111 below.

Figure 1. The relationship between production management and other aspects of the manufacturing operation

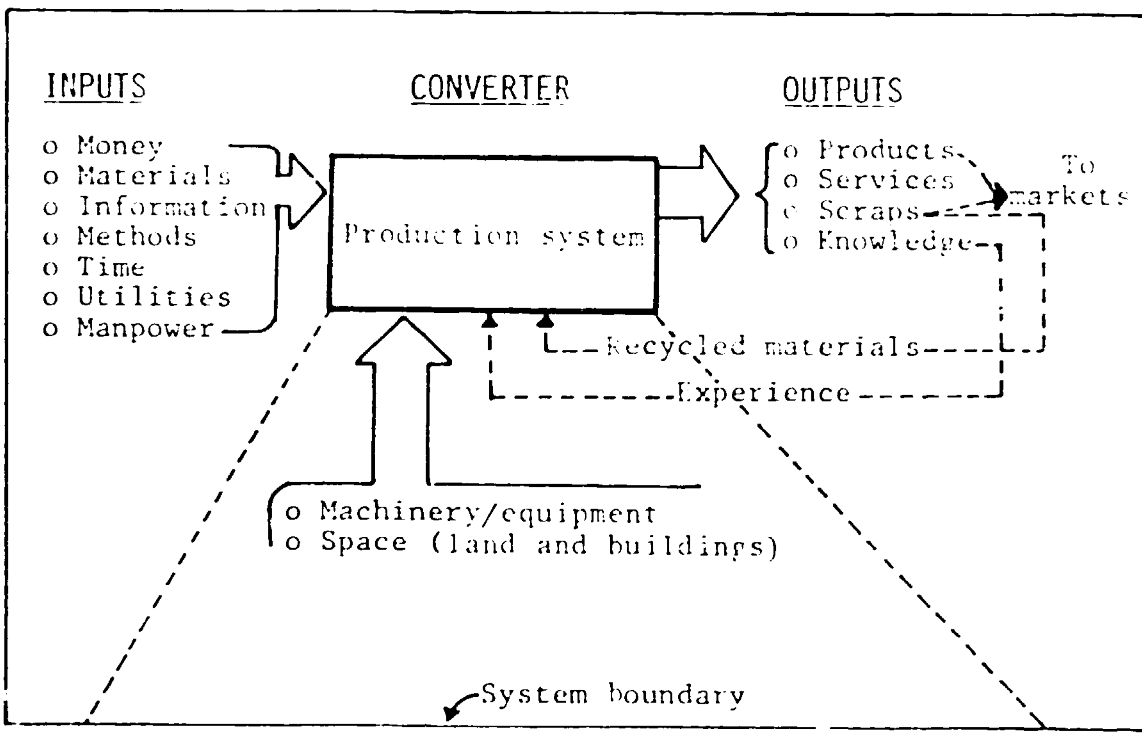


stage of development,[2] marketing should have attained primacy over production and should be allowed to dictate the type, quantity and quality of products to produce and when to produce them. The scheme shown in figure 1 should be useful in dealing with the production-marketing dilemma.

The production system as a "black box"

A "black box" is essentially a converter mechanism which requires a set of inputs and in turn yields a set of outputs. Figure 2 shows a simplified representation of the production system as a black box.

Figure 2. The production system as a "black box"



The black box approach facilitates description of the various types of manufacturing systems available to furniture manufacturers and, within the context of the present manual, makes it possible to itemize in relatively broad terms - without going into the details of the steps involved in converting raw materials into finished products - the various inputs (sawnwood, plywood, adhesives, electricity etc.) needed to generate the required outputs.

Viewing the production function as a black box means starting at the output rather than the input side. Simply put, this means starting with the question: "What to produce?" rather than "Is the production capacity there to manufacture furniture pieces?" At first glance, this sequence of questions may not appear significant. Indeed, there is evidence that the majority of small-scale furniture manufacturing firms in developing countries tend to consider the inputs first. This is underscored by the fact that most such firms - even those that have been in business for a number of years - have not been able to find a product or a product line to specialize in. The application of the basic principle of specialization, therefore, has not gained too much headway in such cases.[3]

Determining what product to produce is not easy, especially in the furniture manufacturing business. The problem lies in considering "furniture" as an end-product in itself. The term furniture refers, appropriately, to a family of product lines. Although in the beginning the small-scale furniture manufacturer may turn out as many products as there are customers, with varying specifications, the owner-manager must not lose sight of the main product line in which he might specialize in the future. One highly successful owner-manager, relating the story of how he started his business, told the author: "I started producing furniture nine years ago. After approximately three years, I began producing office furniture, and after another three I was massproducing office tables." This case illustrates the step-by-step process of attaining a level of product specialization that will ensure the long-term growth of a firm.

Essentially, the small-scale firm derives two major outputs from its inputs: products and services. There are, however, two other outputs of interest: offcuts and knowledge. Scraps are of significance because of the growing concern for better waste utilization and anxiety over the rapid depletion of natural resources. Knowledge is important because of the need to develop the technological capabilities of the workers and thus ensure the long-term survival of the firm. Knowledge acquired in furniture manufacturing can be fed back into the production system in the form of collective experience to support the process of technology build-up.

Looking at the inputs, it will be observed that some are "one time" or fixed (land, buildings, certain types of machinery and equipment etc.), i.e. inputs on which investment is usually made only once, often at the start of the business. Accountants normally refer to these as "fixed costs" since they do not vary, no matter at what level of efficiency they are used. Other input requirements - raw materials, manpower, methodology, time, utilities, information etc. - are of a continuing or recurring nature and demand more attention. Accountants refer to these as "variable costs" since they vary depending on the level of outputs generated in the conversion process. The interaction of the various inputs as they operate in the manufacturing process to produce the desired results is also worth observing.

In orchestrating the inputs to the production process, the basic principles of sound management should be borne in mind, namely:

(a) The fixed or "one time" inputs should be planned meticulously. These require rigorous attention to detail in planning as initial flaws can be very expensive to correct in the long run. Likewise, planning for recurrent inputs should be closely monitored and continually adjusted to attain best business results;

(b) Manpower resources should be carefully deployed. A simple, highly flexible organizational structure will be of considerable help in achieving the goals of the firm. Materials, utilities and the like should be chosen to conform with the manufacturing methods selected;

(c) The plant's existing organizational set-up should be made more effective (and overall production more efficient) by continually motivating the staff and co-ordinating the various inputs;

(d) While this is being done, all the inputs should be monitored in order to ensure their proper and effective utilization.

The performance of all the resources and systems used in the firm should be evaluated periodically and adjustments made where necessary. Most of these principles, insofar as they relate to the production management of a small-scale furniture manufacturing firm, are discussed in more detail elsewhere in this manual.

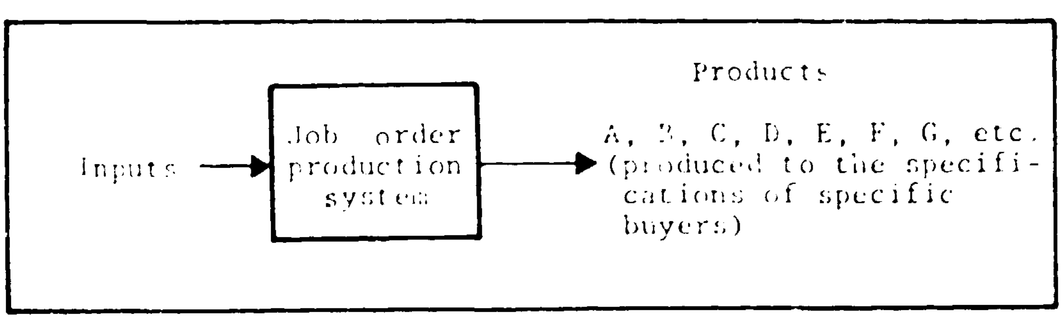
Production systems

Chosing the right type of production system is crucial to the small-scale furniture manufacturer because: (a) he has a very limited margin for strategic error, and (b) each system makes unique demands on his time and skill as an owner-manager. Various options are open, but these, generally, can be classified in two broad categories: intermittent and continuous. An intermittent production system is simply one that is responsive to specific orders or the demands of specific buyers; a continuous system is one whereby the firm manufactures to stock (i.e. without a given buyer at a given time). The majority of small-scale furniture manufacturers in the developing countries employ intermittent systems, at varying levels of sophistication, irrespective of whether they are exporting their products or not. A "job order" operation is a good example of an intermittent system, and a mass production operation, whether rigid or flexible, is an example of the continuous type.

Job order production system

Employed by most small-scale furniture manufacturers in developing countries, the job order system features the production of custom-built pieces of furniture, tailor-made to the specific requirements of buyers. It is characterized by relatively small-volume job orders, the need for highly and multi-skilled workers, and the extensive use of general-purpose machinery and equipment. Because using this system entails working with a wide variety of product designs, enterprises employing it often complain of low productivity, are unable to attain a high degree of specialization, and experience considerable fluctuation in their manufacturing time-tables. Figure 3 is a schematic presentation of a job order production system.

Figure 3. Job order production system

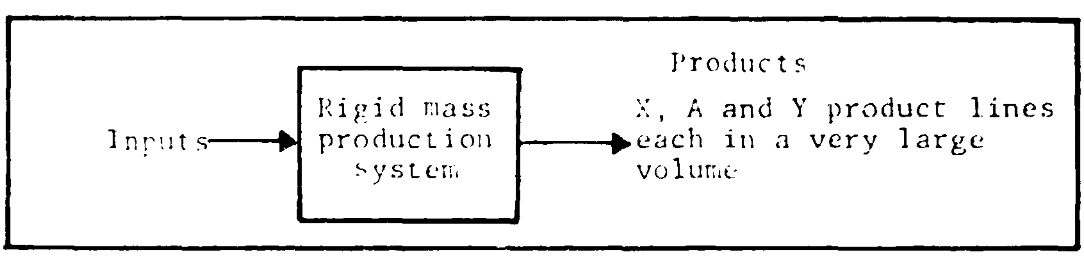


This type of production system offers, nevertheless, an attractive way for firms with limited capital resources to start operations. The problem lies in the extended use of the system, failure to identify a product line to specialize in, and consequently inability to move to a higher level of production. Manufacturers employing this type of system should, at the outset, deploy their workers on the basis of the skills or crafts they possess, then, after some time, reorganize them according to the various stages the products have to pass through, making sure that all the necessary skills are available for each stage. Obviously, this cannot be achieved overnight. Some small manufacturers need five to eight years to evolve from a skills/crafts to a stage-type organization. In the meantime, attempts should continually be made to standardize tools, jigs and materials to the point where a definitive if limited range of products can be tackled by the production system. This will trigger the shift from job order to other production systems.

Rigid mass production

Rigid mass production is employed by firms producing few but uniform lines of products in large quantities for specified markets. It is characterized by a relatively high degree of specialization in terms of the product lines handled; the sophistication of the machinery and equipment used; and the employment of machine operators rather than skilled craftsmen. Other features are longer production runs and relatively large quantities per production batch. In view of the high levels of inventories involved, considerable storage space must be set aside for raw materials, semi-finished and finished products. The focus of attention is on marketing rather than production as firms engaged in this type of production manufacture to stock, as opposed to having a ready buyer before the start of manufacturing, as is the case with job order production. Figure 4 is a schematic presentation of a rigid mass production system. It will be observed that the final products of this system - in addition to the tools, jigs and materials employed - are standardized and uniform. Uniformity, in as few product lines as possible, is the key to rigid mass production.

Figure 4. Rigid mass production system

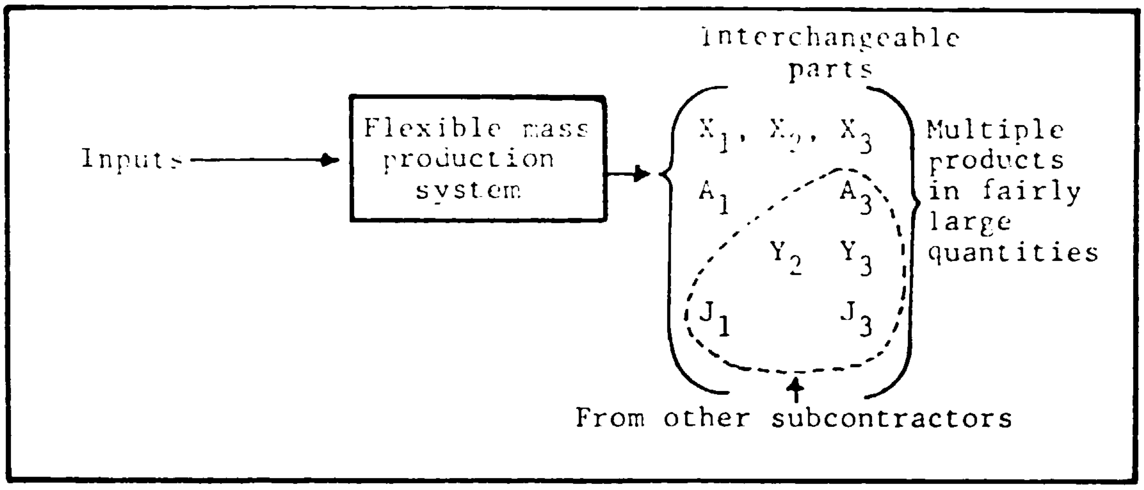


Flexible mass production

The flexible mass production system features the manufacture of intermediate parts which can be interchanged to produce a variety of products in large quantity. Just as the end products are standardized in rigid mass production, the parts are standardized in flexible mass production in order to make possible a wide diversity of product lines.

An example of the latter type of production is provided by the small-scale firm that decided to manufacture a relatively limited range of office furniture. It specialized in making table tops, and subcontracted the fabrication of the legs. Each of the several subcontractors involved suppl ed the firm with one to three different types of leg, made of a variety of materials, including chrome-plated steel. The firm then applied the legs, interchangeably, to the small variety of table tops it produced. The various combinations made possible in this way yielded a highly diversified set of product offerings. Other examples of flexible mass production are provided by small firms that produce "completely knocked down" (CKD) furniture pieces for subsequent assembly by subcontractors. Figure 5 is a schematic presentation of a flexible mass production system.

Figure 5. Flexible mass production system



Application of this system requires an in-depth analysis of product lines to determine the pattern and logic of the product diversity. This pattern, once established, will facilitate the production of the minimum number of standard parts needed to generate the maximum number of finished products. Although the flexible massproduction system has not gained wide acceptance by the small-scale furniture manufacters in the developing countries, it can provide a way in which relatively large firms can complement the activities of, rather than compete with, smaller firms.[4/]

The choice of production system

It will be clear from the foregoing that the production system chosen will depend to a great extent upon the type, requirements and characteristics of the markets aimed at, as well as the product mix, the processes involved, and the firm's potential for expansion. In making this decision, it must be borne in mind that the systems discussed above can also be viewed as stages in the evolution of a typical small-scale furniture firm. Thus, as may be seen from figure 6, the job order type involves a relatively low level of sophistication compared with the flexible mass production type.

The checklist shown in figure 7 may be found useful in choosing a production system or checking whether the system being employed is the appropriate one.

Figure 6. Production systems as stages in the evolution of the small-scale furniture manufacturing firm

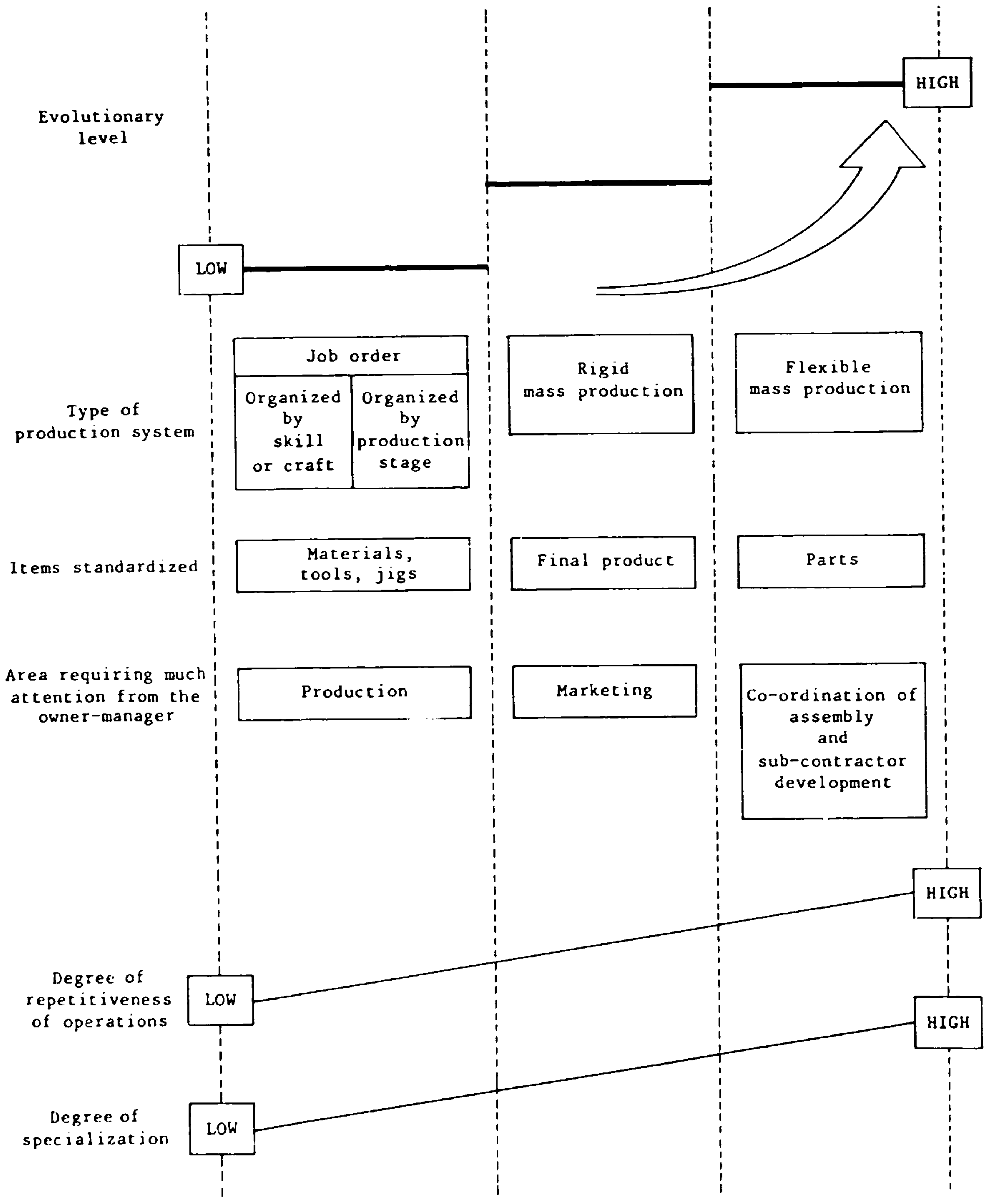


Figure 7. Checklist for choosing a production system

	Type of production system		
Parameters	Job order	Rigid mass production	Flexible mass production
1. Type of market	Limited (local)	Less limited	Unlimited (local and foreign)
2. Customer needs	Product variety in small volume per order	Volume rather than variety	Volume and variety
3. Products/ production volume	Highly diversified. Small volume per order	Limited number of product lines. Large volume	Parts and combination of parts. Variety of products in large volume
4. Type of machinery and equipment	General purpose	Combination of general purpose and special	Highly specialized. Use of component machine
5. Time needed to produce a new product	Relatively short. Life cycle is very short	Longer time. Life cycle tends to be longer	Very long time. Relatively short life cycle
6. Capital requirement	Low	Medium to high	High to very high
7. Break-even points	Low	High	Very high
8. Materials inventory	None to low	High	Very high
9. Cost estimators	Owner-manager	Part- to full-time	Cost estimating group
10. Type of workers needed	Craftsmen and skilled workers	Machine operators	Parts specialists,[a/] subcontractor and co-ordinators
11. Production support staff	None to very limited staff functions	Staff experienced in the analysis and control of costs, time, materials, wastes etc.	Qualified staff, including personnel to provide subcontractor assistance and co-ordination
12. Major concern of production manager	Production of an entire product or job order	Manufacturing	Assembly and orchestration of various parts by subcontractors

a/ Personnel who by training or experience (e.g. as machine operators) are able to suggest which parts/components of a product can be economically manufactured by the firm and which should be subcontracted out.

The proper selection of a production system is a critical matter as subsequent shifting from one system to another can be very expensive as well as time consuming. A case in point is provided by a small-scale firm known to the author which has started on a job-order basis, catering to a local regional market. This firm will require large infusions of capital, managerial and technological know-how in order to be able to export furniture pieces to its ultimate goal, the European markets. Eventually, the situation will call for a "happy" compromise between the firm's short-term goals (limited market, fast returns on investment, experience gained, know-how acquired etc.) and its long-term goals (export markets, rationalization of production facilities, quantity and volume as opposed to product diversity etc.). The firm must likewise consider: which product lines to specialize in; the initial capitalization required; the target markets and their characteristics; and the technology available to it.

Production management problems

Poorly-managed production is responsible for a number of problems that may be catagorized in the following broad terms:

(a) Planning-related problems. These result from inadequate planning of production requirements. Symptoms include persistent raw material inadequacy; inability to deliver on time and in the right quantity and quality; failure to meet customer specifications; prolonged use of obsolete and inefficient machinery and equipment; lack of room for expansion; and inadequate working capital.

(b) Control-related problems. Lax or inadequate control in production results in low volumes of manufacture and high rates in: quality rejection; raw materials inventory; cost of production; pilferage; raw materials spoilage and improper utilization; excessive energy use; machine and equipment breakdown etc.;

(c) Productivity-related problems. Small-scale furniture manufacturing in developing countries suffers from the inherent disadvantage of being obliged to cater to limited, local markets; hence the use of uneconomic scales of operation, the underutilization of inputs, and the generation of suboptimal outputs. Productivity-related problems, some of which may be traceable to poor planning and control practices, include: inordinate dependance on rapidly depleting indigenous raw materials; excessive labour costs; relatively low yield per unit volume of sawn timber; low ratio of direct production time to total time available for production; and low output per worker compared with that of other firms of similar size;

(d) Organization-related problems. Problems linked to the organization and direction of the enterprise, as well as to the integration of its activities, further complicate the already difficult role of the small-scale furniture manufacturer, who is often not only the general manager of the business, but its purchasing manager, overall supervisor, financial comptroller, marketing manager and treasurer. The demands of the production function on the entrepreneur's time can be reduced or expanded, depending on how well he organizes, directs, delegates and integrates all the limited resources available to him. Common complaints that indicate the presence of such problems include: "I have to explain to all my workers how this job should be done". Or: "My supervisors cannot concentrate on supervising because they, in fact, are our most efficient workers". Or: "Too much time is spent chasing around the plant facilities". Or: "I don't think my workers understand my predicament";

(e) Technology-development-related problems. In order to ensure survival and long-term viability, the small-scale furniture manufacturer must be concerned not only with productivity-related issues but also with new technological developments in software (management know-how) and hardware (new processes, machines and equipment) and the need to adapt to such developments. A considerable number of small-scale manufacturers have started out using only basic manufacturing know-how with the hope of gaining more experience with time. That may not be a viable strategy for technology development, however, for although furniture manufacturing may be considered an "old" industry, much new technological know-how is being evolved in the field. Examples include new wood-printing and advanced gluing techniques, innovations in protective packaging, and the development of multiple spindle machines and low-cost automation.

A stated earlier, this manual is not intended to provide a cure-all for these production-management-related problems. Rather, the aim is to suggest guidelines for avoiding or minimizing the effects of the problems and to promote awareness of the options or solutions available to the small firm owner-manager.[5/]

II. PLANT LOCATION AND LAYOUT

Plant location and layout represent two other decisions of strategic concern to production management. Guidelines for arriving at the relevant decisions are offered in this chapter.

With regard to plant location, the following issues are dealt with:

(a) How important is the plant location decision to the small-scale furniture manufacturer?

(b) What factors should be considered in determining the appropriate location for the plant?

(c) How would the small-scale manufacturer choose between alternative sites?

In di ussing plant layout, the following issues are considered:

(a) What are the options insofar as layout is concerned?

(b) What type of layout should be adopted for small plants already in existence or about to be set up?

The location decision

Determining where best to locate is a problem that owner-managers face periodically since products, processes, markets and even the sources of raw materials change with the passage of time. A firm located in what was once a desirable area may suddenly find itself cramped for space or forced to assume high delivery costs because the markets or the suppliers of raw material have moved. Since it is so costly to move or relocate, site selection must be a long-term commitment, like the choice of production system. No location can guarantee permanent success, but certainly, some locations inhibit it. Any decision regarding location should be based on a critical assessment of the desirable and undesirable aspects of the various location alternatives.

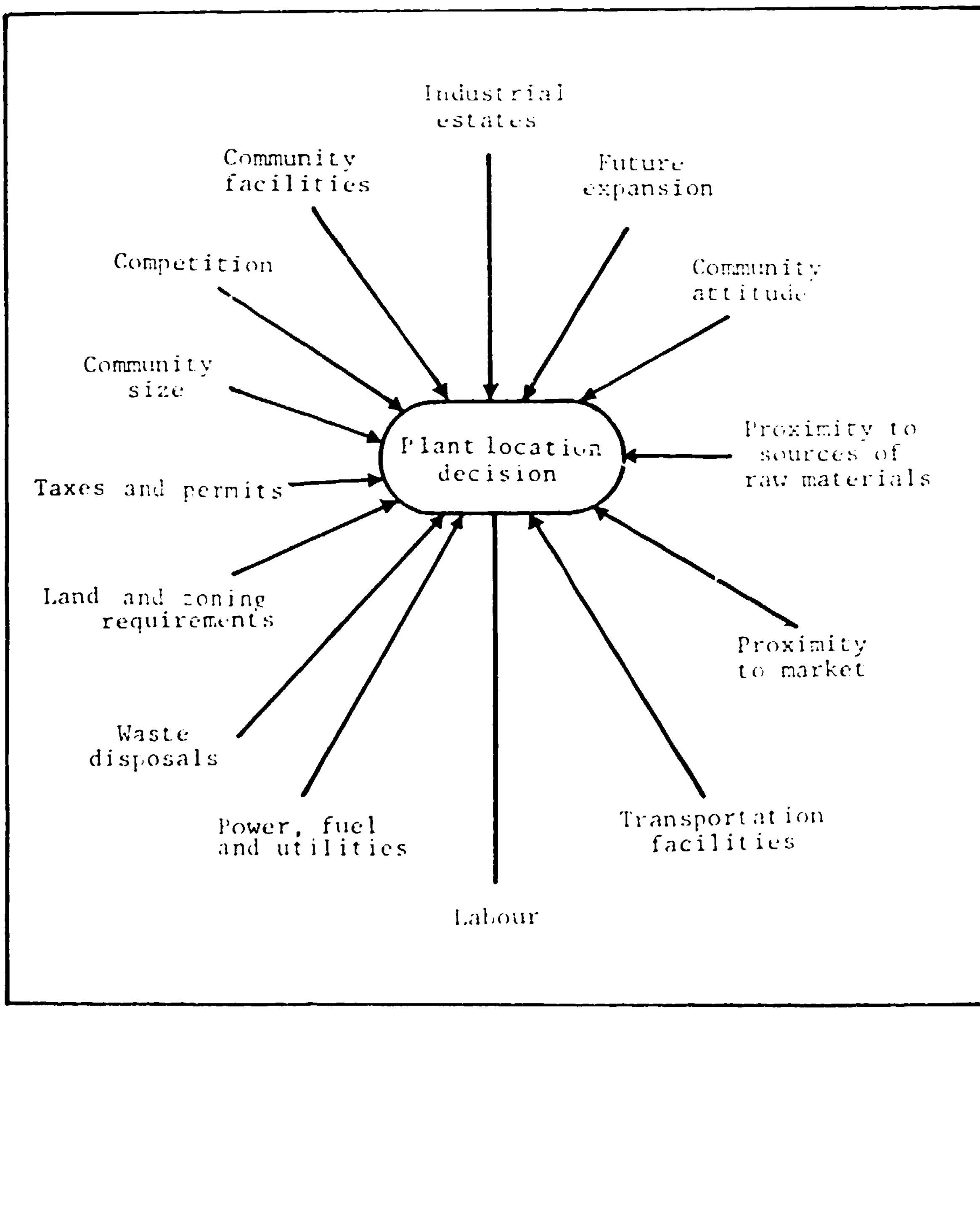
Factors affecting the location decision

The ideal location has been described as one where the unit costs of manufacturing and distribution are at the minimum and where prices and volume of sales will generate maximum profit. The various factors, tangible and intangible, quantifiable and unquantifiable, affecting the location decision are illustrated in figure 8.

These factors in general affect the unit costs of manufacturing, and hence have a bearing on the competitive position of the firm, as discussed below.

1. Proximity to sources of raw materials. The typical small-scale furniture manufacturing firm tends to be materials-intensive, but, unlike its larger counterparts, it does not have the wherewithal to sustain a logging operation and primary sawmilling facilities. A site chosen for its proximity to the basic source of raw materials in time may be sorely affected by the deforestation of the area. Similarly, a firm using primary sawmills as its source of sawnwood will be affected as deforestation forces the sawmills to relocate. In such circumstances, raw material acquisition can suddenly become expensive.

Figure 8. Location decision factors



2. Proximity to market. This factor greatly affects the costs of distributing the finished product. In developing countries, the "centre of gravity" of the small-scale furniture manufacturer's markets is constantly changing, and at a relatively fast rate. Construction activities, on which the market for furniture pieces may hinge, tend to move from developed to underdeveloped areas, from heavily urbanized to rural areas. In this case, the flexibility allowed by the firm's smallness may prove to be an advantage.

3. Transportation facilities. This factor has two major components, i.e. availability and costs. One advantage of small-scale industries in general is the relative ease in locating them in the rural areas of developing countries. Initially, the question of transportation facilities may not pose a problem, if the market coverage radius is small; it may become one, however, as market coverage expands., The cost of transporting raw materials and finished products can greatly affect pricing schemes and hence the competitiveness of the firm in the long run.

4. Labour. Labour costs, which may vary from place to place within a country, are certainly an important factor in the location decision. As discussed earlier, the job-order type of production system tends to be labour-intensive, i.e. the labour component of the total production cost is relatively high, hence the importance of this factor. Labour aspects that must be taken into account include training costs, recruitment costs (in some areas where the skills needed are not available, even the relocation costs of labour must be considered), attitudes towards work, and working habits.

5. Power, fuel and utilities. The costs of these also usually vary within a country. Related matters to be reckoned with are reliability, frequency (in rural areas in some developing countries electricity is available for an average of only 4 hours in the working day) and quality (the voltage of electrical supply in rural areas can fluctuate by as much as ± 30 per cent of the rated values).

6. Waste disposal. This factor looks deceptively insignificant, but small-scale furniture manufacturing operations can incur considerable expense in managing (e.g. installing a dust collecting system) and disposing of wood wastes. Present-day concern with the quality of the working environment and pollution control also make this an important factor in site selection.

7. Land and zoning requirements. The availability, cost and quality of land for plant site is another major factor. Zoning legislation recently introduced in some developing countries must be reckoned with. A firm establishing itself in what appears to be a good location for the purposes of manufacturing may find itself in a residential zone after five years. Relocating in this case will be very expensive.

8. Taxes and permits. The types and costs of the taxes, licences, and permits needed to operate a small manufacturing oncern generally vary from place to place within a country.

9. Community size. The firm should be located within or very close to an existing, suitably sized community in order to keep the expense of providing housing for the workers, transportation services etc. to a minimum.

10. Competition. One distinct and negative characteristic of the small-scale furniture manufacturing firm in developing countries is the tendency to locate in areas in which there is already too much competition for the local markets. It should be remembered that while a certain amount of competition is needed to sharpen managerial skills, an overdose may be detrimental to long-term survival. Locating in an area that already has a surfeit of competition means additional expenditure on promotional, advertising and other marketing-related activities.

11. Community facilities. The facilities available within a given community must likewise be considered. These include, in addition to having facilities for medical assistance (how far is the plant from the nearest first-aid clinic), recreation, practice of religion, education, and entertainment.

12. Industrial estates. As a rule, the small-scale entrepreneur should favour locating within or close to an industrial estate. An estate is composed of plots of land (construction sites) or ready-built factories equipped with all necessary services and facilities. In the latter instance, the entrepreneur can settle in, hire staff on the spot, set up machines and start commercial production. Location within an industrial estate hastens the installation process and offers the added benefit of "linking" with other manufacturing plants in the area. Policy-makers in many developing countries are contemplating setting up specialized zones for their small-scale industries. With respect to the furniture manufacturing industry, the idea of setting up "furniture villages" is being examined in certain areas.

If a country or area has no industrial estates, the available infrastructural facilities should be thoroughly investigated to ensure that they are sufficent to support a furniture manufacturing operation. By this is meant the availability of potential subcontractors, small workshops for the maintenance of equipment and tools, suppliers of hardware and other materials, communication facilities (e.g. telex) and the like.

13. Future expansion plans. In deciding on plant location, allowance should be made for future expansion.

14. Community attitudes. These refer, in this instance, to the predisposition of a given community to a business undertaking, sometimes based on traditional values or mores. This may be negative ("We don't want a coffin manufacturing company here; it brings bad luck") or positive ("Your project is just what we need in order to turn our waste material into cash").

The aim of the small-scale furniture manufacturer in selecting a plant site should be to minimize the sum of all the costs involved within a specific location, not only for the immediate future but also for the long run. In this respect, some of the factors listed above may be intangible and difficult to quantify objectively in terms of immediate cost. They should, however, influence future costs.

Checklist for deciding on plant location

A simple checklist arraying all the important factors applicable to each alternative site can be an effective tool in deciding on plant location. The following considerations should be kept foremost in mind.

(a) Exchanging one site for another, perhaps more appropriate, one. In some cases, the entrepreneur may already own a piece of real estate, either through inheritance or by direct purchase. It would be over-simplifying the problem of plant location, however, if he were to set up a plant on this property without exploring the possibility of selling or exchanging it for another that might be more appropriate to his long-term needs;

(b) Vertical expansion. It may also be possible to remain in an existing, but cramped, location and to expand upwards, adding a second floor. As discussed later in this chapter, under plant layout in the context of furniture manufacturing, this alternative may be a palliative rather than a remedial measure, however.

(c) Expanding subcontracting activities. If a business is periodically defined in very specific terms, it will be observed in time that it has accumulated certain activities which are not really its concern. Instead of expanding to house these additional, and maybe unnecessary, activities, it may be worth considering remaining in the present location, be it a trifle cramped, and utilizing the sub-contracting option.

(d) An entirely new location. This point is best illustrated by the case of the small-scale furniture manufacturer who specialized in woodworking operations. He located his firm on a site owned by him, thinking that owning the property would automatically lead to cheaper operating costs. In the mid-1970s, he decided to take on the production of cane furniture, in spite of the fact that he was located a considerable distance from the port where the cane materials were landed. Initially, this did not present much of a problem, but as the volume of production increased and fuel costs rose he was obliged to look for a more appropriate site. To avoid such a situation, the factors affecting plant location must be considered in their totality, using a check-list such as the one presented in figure 9.

In figure 9, the factors involved in the plant-location decision have been subdivided into quantifiable (where numerical data can be obtained to substantiate the decision-making process) and non-quantifiable (where subjective approaches are needed to arrive at a decision) factors. The former, for convenience, have been divided into two components: fixed capital requirements and unit production costs. The user should make his own assumptions in estimating the items involved in the unit production costs. In dealing with the non-quantifiable factors, the following subjective criteria may be used to rate the desirability of a location: A = Excellent; B = Very satisfactory; C = Satisfactory; D = Fair; E = Poor; and F = Very poor. It should be noted that sometimes just one criterion - even a minor one - may outweigh all others, depending upon the degree of specialization of the firm (in terms of products, markets and raw materials), and the manufacturer's viewpoint.

Criteria for effective plant layout

As soon as it has been decided where to locate the plant, the next important task is to arrange its facilities. This entails the provision and planning of working space for machinery, other equipment, production and other personnel, support services, and storage. Activity aimed at attaining the most efficient and economical physical arrangement of the plant is known as plant layout. A good plant layout:

- Provides the most advantageous and economical work flow.
- Reduces materials movement to a minimum.
- Utilizes all available space effectively.
- Is flexible and allows room for adjustment.
- Reduces delays and work stoppages.
- Facilitates the maintenance and repair of machinery and equipment.
- Makes for improved control and supervision within the shop.
- Maximizes the job satisfaction and safety of the workers.

An example of the consequences of poor layout is provided by the small-scale furniture manufacturer who set up a plant to manufacture cheap, low-quality household furniture and later diversified to include the intermittent production of doors, jambs, cabinets and similar articles. In so diversifying, he forgot to make the necessary physical adjustments to his production facilities. It took two small-industry extension officers to diagnose the cause of his persistent low productivity.

Figure 9. Plant location checklist

	Factors	Location alternatives A	B	C	D	Remarks
Quantifiable	(a) Fixed capital requirements: Land costs Building and other structures Ground improvements Right of way Equipment Other fixed cost elements					
	Total					
	(b) Unit production costs Raw materials a/ Direct labour a/ Overhead costs a/ Transportation Electricity Communications Salaries/wages Water Taxes, permits etc. Depreciation Others					
	Total					
Non-quantitiable	(a) Community attitudes (b) Community facilities (c) Competition (d) Potentials as a growth centre (e) Community size (f) Industrial estates (g) Other					

a/ Estimates should be based upon user's assumptions.

An appropriate plant layout can contribute significantly to enhancing productivity and reducing unit production costs. This is because the physical arrangement of the manufacturing facilities will determine the movement of materials, semi-manufactured products etc. inside the firm. It must be remembered that such movement only adds cost without improving the value of the product. Hence, materials back-tracking must be minimized if not totally eliminated.

Plant layout development in small-scale furniture manufacturing firms in developing countries is at what may be considered the evolutionary stage, perhaps because of the limited start-up capital available in most cases. The owner-manager will initially, as a rule, purchase a band saw as his basic piece of machinery and start producing saleable products. At a later stage, say after two years, he may add another type of machine - e.g. for stock preparation - and so on. The resulting layout, therefore, is not systematically planned but evolves depending on the circumstances of the firm. This practice usually leads to problems related to low productivity and high manufacturing costs and thereby eliminates the distinct low-overhead advantage of the small-scale operation.

Types of layout

Layouts for small-scale furniture manufacturing operations are basically of two types: process and product.

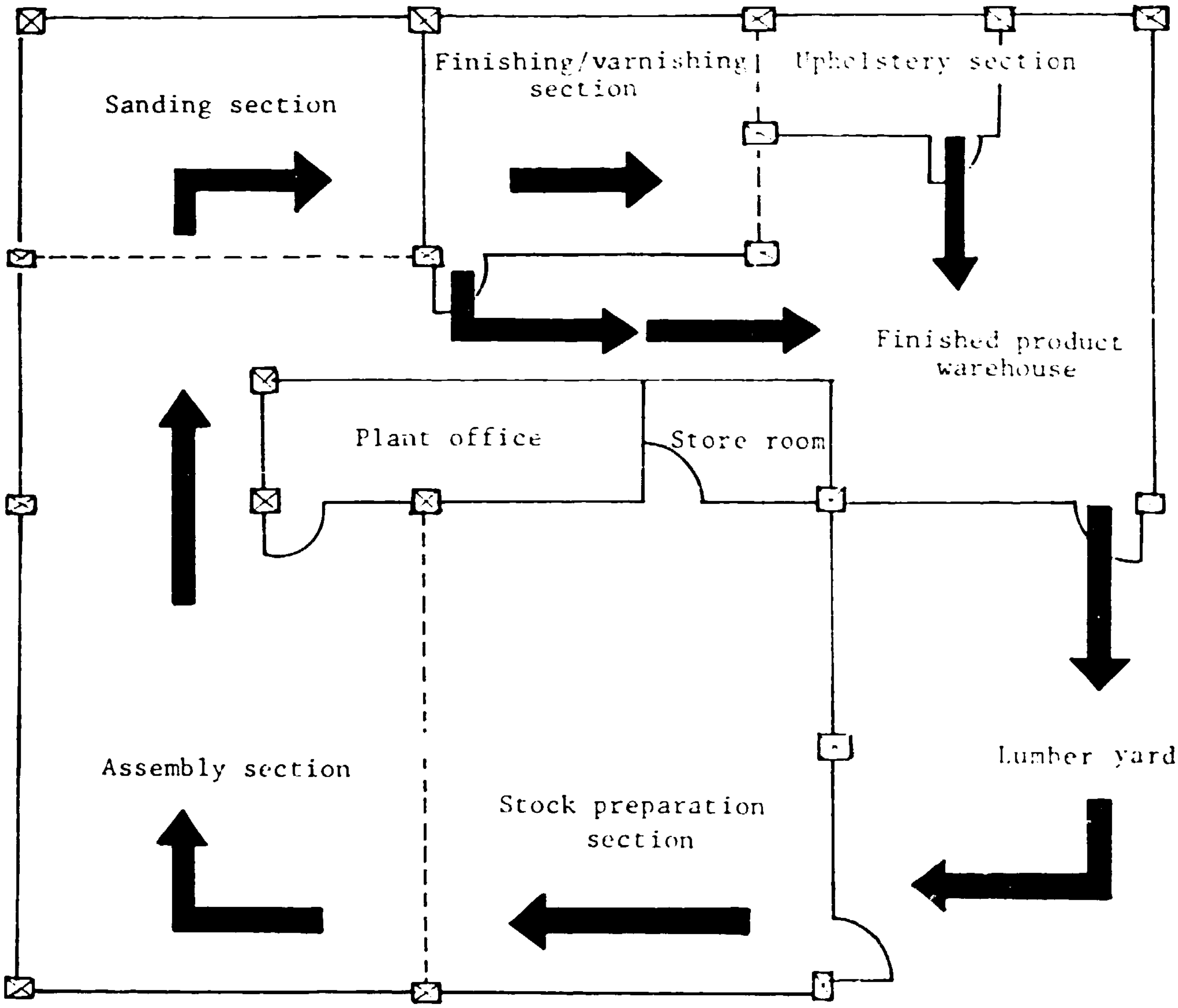
Process layout. In a process layout, all machines and equipment performing similar tasks or used for similar processes are grouped together in one area or department. A firm employing it may, for example, lay out all stock preparation equipment in one area and all ssembly equipment in another. Firms using the intermittent type of manufacturing operation usually favour this layout. As a rule, it is chosen where a great many products share the same machines or where a product is being manufactured in relatively low volume. Moreover, when a standard product is not being produced in large quantity, process layout is usually more desirable because of the flexibility it allows. Figure 10 illustrates a process layout.

In intermittent production, process layout offers a number of advantages. These include reduced capital investment (because there is less duplication and maximum utilization of machines and equipment); greater flexibility in terms of tasks performed; more continuity in manufacturing activity, even when a machine breaks down; and generally - for small firms producing several products in relatively small quantities - lower production costs.

Process layout, however, also has the following drawbacks: difficulties in scheduling, routing and controlling manufacture (since almost limitless combinations of sequences can be used in processing similar items); high materials handling costs; and problems of co-ordination and control resulting from the wide range of variations in manufacturing.

Product layout. This type of layout is not often found in small-scale furniture manufacturing operations in developing countries. According to this layout, all the machines and equipment needed to make a specified product are set out in the same area and in the sequence employed in the manufacturing process. It is used mainly by firms having a high demand for products that are more or less standardized. It is very useful therefore in firms using the continuous type production system. Figure 11 shows a product layout in a firm producing flush doors and door jambs.

Figure 10. Process layout



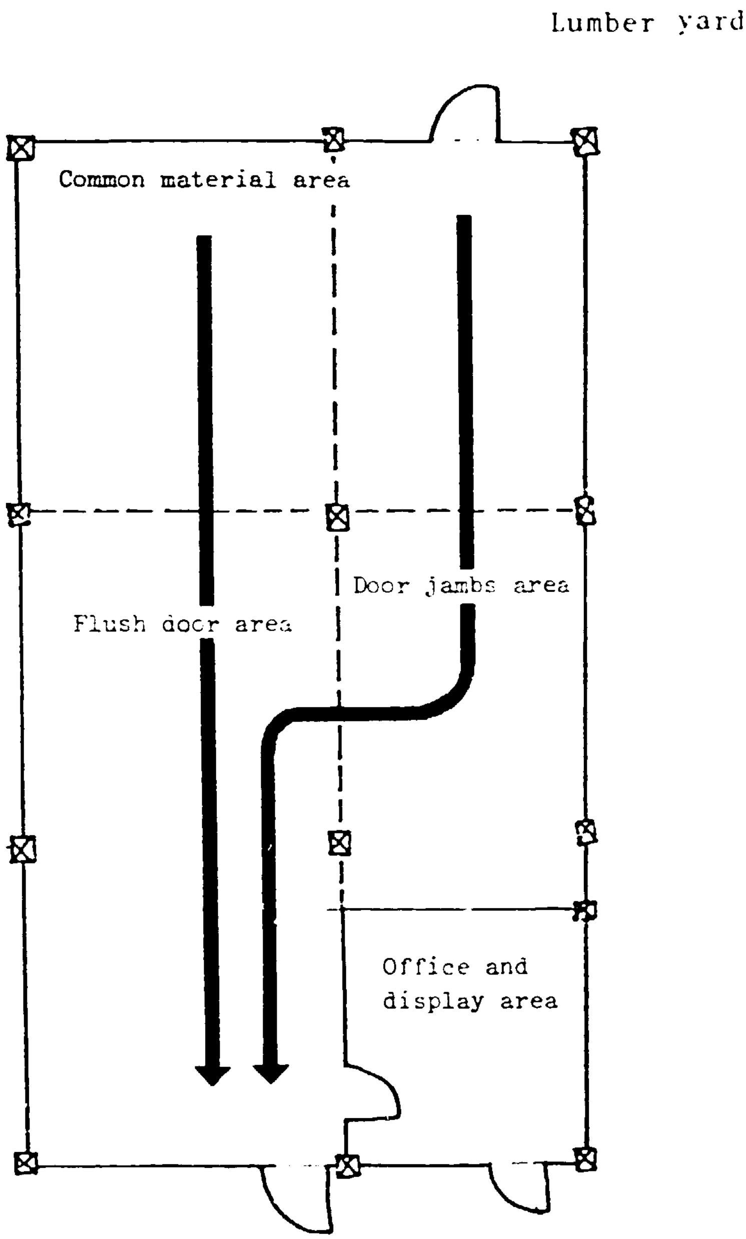
Key: Posts

Imaginary dividing line

Theoretical flow of materials

Note: Not drawn to scale.

Figure 11. Product layout



Key: Posts

Imaginary dividing line

Theoretical flow of materials

Note: Not drawn to scale.

Product layout makes automation and mechanization more feasible; encourages labour specialization; eliminates product routing problems; makes labour and material flow more easily controllable; reduces the need for area inspection (because machines perform distinct operations); permits better utilization of floor space; and makes for fewer materials handling problems.

On the other hand, it has the following disadvantages: it is relatively inflexible; it is economically feasible only when manufacturing in extremely large quantities; it is useful only for a given product where the balancing of production lines is possible; it may be costly for products that are susceptible to changes in trend, technology and preferences (because of the need to modify and replace special-purpose equipment); and it requires higher capital investment (because of the machinery duplication involved and the high cost of special-purpose equipment).

There are two variations of the product layout, namely: fixed layout and group layout. In the former, the raw material remains in the same position throughout the processing, the machines and equipment being moved into place beside it. This type of layout is used when the product under manufacture is bulky and heavy or when only a few units are being made at a time. Wooden carvings, statues or boats are some products for which this type of layout is used. Group layout has only recently been introduced, as a result of increasing concern with the working environment. In this layout, all personnel engaged on a given product or part of a product are grouped together as a team and provided with all the machinery and equipment needed to complete the work. The workers are encouraged to divide and distribute the work among themselves and to interchange jobs to the extent possible.

Concepts in improving plant layout

Whatever layout is adopted, the objective should be to ensure that every square centimetre of the plant generates profit. To attain this end, the following may be useful:

1. Concept of shortest travel distance. The building housing the manufacturing operation should be on one level only. Partitions or walls between sections should be avoided (with the exception of the sanding, finishing and varnishing sections). Likewise, pillars, posts and corners should be avoided whenever possible. This facilitates the unhindered transport of timber and other materials from one process to another.

2. Concept of three-dimensional space. Maximum economy is obtained when all available space is effectively utilized, vertically as well as horizontally.

3. Concept of one-way flow. The best layout is one in which working areas are arranged in the following sequence: stock preparation; parts processing; parts assembly; finishing; and packaging of finished products.

4. Concept of satisfaction and safety. The best layout is one that allows for future expansion or the rearrangement of manufacturing facilities with a view to accident prevention, at the lowest cost and with the least inconvenience.

5. Concept of total integration. The best layout is achieved when manpower, materials, semi-manufactured products, machines, and other diverse elements are so integrated that they form a well-arranged and functional whole.

Checklist for identifying plant layout problems

The simple checklist given below may be found useful in evaluating an existing plant layout or preparing a new one.

Materials handling

1. Are tool cribs located in such a way as to save time in exchanging tools?

2. Are materials, jigs, fixtures, patterns etc. easily accessible?

3. Can materials handling cope with the entire range of sizes of timber for new job orders?

4. Do new materials or parts purchased for a new job order require special storage facilities?

5. Can materials handling be further improved?

6. Is storage space for inflammable finishing materials properly constructed?

7. Have ramps been installed to facilitate movement of materials?

8. Are door clearances adequate for manpower and materials movement?

9. Can pallets be used to facilitate movement of materials, semi-manufactures, parts, finished goods etc. from one work station to another?

10. Are concrete floors in suitable condition to accommodate the use of pallet transporters? (I.e., are they clear of cracks and other defects?)

Maintenance

1. Is the space around each machine sufficient to permit storage of components on pallets before and after machining and still leave room for the proper operation of the machine, fully extended?

2. Are machines and equipment installed with a view to facilitating maintenance, repair and servicing?

3. Are power connections easily identifiable?

4. Are measures being taken to deal with such "house-keeping" problems as accumulation of dust and wood chips; ineffective storage of semi-finished products; or difficulty of access to certain floor areas?

5. Are all power, lighting, pneumatic ventilating (especially in the finishing area) and other service controls accessible?

Personnel facilities

1. Are lavatories, locker rooms, washrooms and drinking facilities adequate and centrally located?

2. Is the plant properly painted (i.e. relaxing to the eyes of the workers)?

3. Are lighting and ventilation sufficient to allow employees to work in comfort?

4. Are the fumes of the finishing department and the sawdust in the stock preparation and sanding areas properly contained?

5. Do the dimensions of the aisles conform to safety regulations?

6. Are entrances and exits properly located?

7. Does machine travel extend into the aisles?

8. Does the width of the aisles permit two-way traffic of personnel?

Production control

1. Will current production volume meet sales targets?

2. Is there enough space around the machines to permit loading and unloading of raw materials and semi-manufactured products?

3. Are stock rooms of adequate size?

4. Are inspection booths and stations located where they will be most effective?

5. Can inspectors carry out their tasks without feeling cramped or constrained?

6. Will major design changes seriously affect production operations?

7. Is the concept of production flexibility being given proper consideration?

8. Are all personnel concerned co-operating in whatever efforts are being undertaken to improve the plant layout?

9. If a new layout is envisaged, have all the costs been properly estimated?

III. MATERIALS MANAGEMENT AND INVENTORY CONTROL

Materials management problems

The typical small-scale furniture manufacturing firm in a developing country is usually plagued by a multitude of problems related to materials management and inventory control. These affect not only the main areas of production management, but other areas as well, and sometimes threaten the very survival of the firm. The problem of unavailability of raw materials can be compounded by too much dependence on traditional raw materials. In addition, research in developing countries on possible substitutes for traditional raw materials for furniture manufacturing has been relatively slow, as has been consumer response to such substitutes. One area that the small manufacturers in developing countries often overlook, however, is the possibility of collective action to promote acceptance of non-traditional materials.

Furthermore, furniture manufactured by small firms tends to be too material-intensive - rather than labour-intensive. The average small firm in a developing country can attribute 40 to 60 per cent of its total production costs to raw materials, whereas the relatively low cost of the labour available to it is an advantage that it can use in its favour when competing in the world markets.

Another important area of concern is raw materials inventory control. The small-scale furniture manufacturer as a rule stores either too little or too much raw material. Too little raw material in stock results in unnecessary work stoppage and expensive delays in delivery. On the other hand, over-stocking of raw material leads to an unnecessary drain on working capital and if done on a large scale may push prices upwards.

Scope of materials management

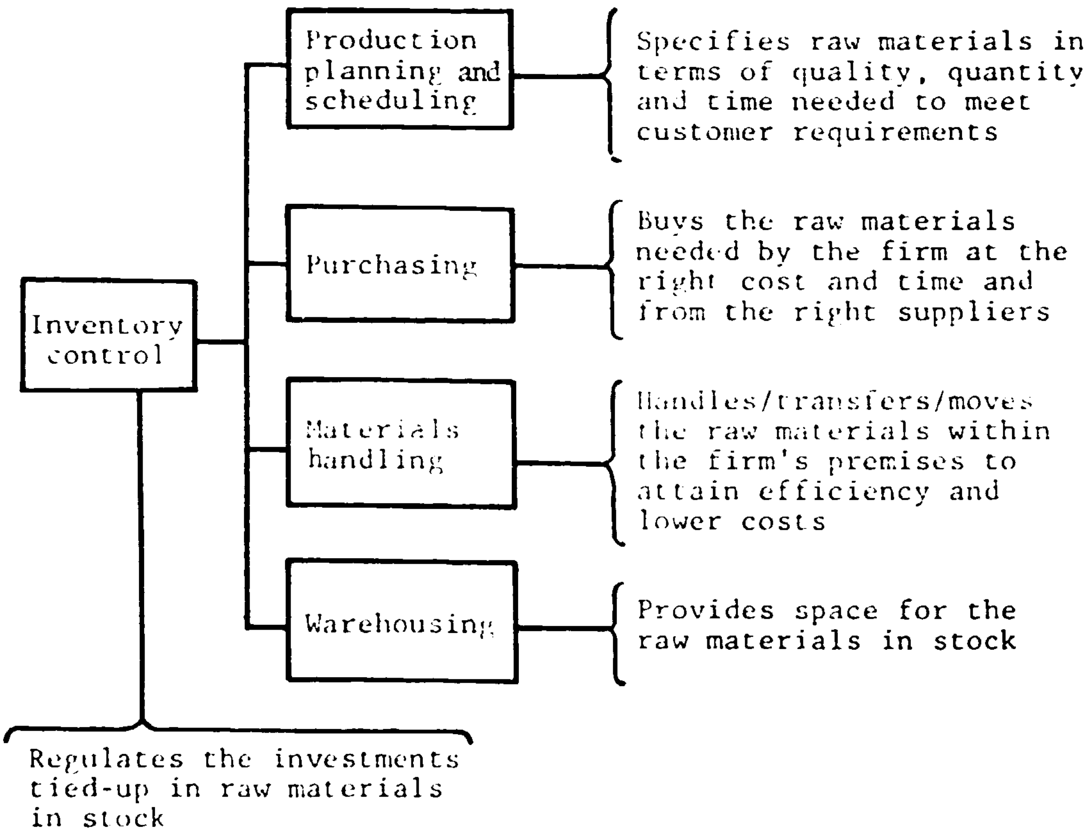
This particular area of production management involves managing the acquisition, utilization, movement, handling and distribution of various inputs to the manufacturing operation. These include: raw-materials, work in process, semi-finished goods, offcuts and waste, finished products, auxiliary materials, tools, jigs, fixtures, and full-scale patterns.

Materials management also covers production planning and scheduling; purchasing; materials handling; warehousing and storage; and inventory control. It normally begins with the production planning stage of the operation, where materials are generally specified in terms of quality, quantity, time needed to finish etc., depending on the design of the product and the job orders in hand. Here, materials management ensures that materials will be available for processing when they are needed, as specified in the job order or production plans. (The mechanics of production planning and scheduling are discussed in chapter VIII below.)

Materials procurement, which should allow some "lead time" (the interval between the time the material is ordered and the time it is received by the firm), is the responsibility of the purchasing unit. This unit locates sources, negotiates prices and arranges for deliveries.

As soon as the materials have been received and inspected at the firm, the materials handling unit takes over and sees to it that they are transferred from one work station to another in the most expeditious way.

Figure 12. Scope of materials management



Warehousing is that part of materials management responsible for providing space for incoming raw materials, in-process goods and finished goods, as well as the drying area.

Inventory control monitors the financial investment tied up in stocks of raw materials. Figure 12 is a schematic presentation of the scope of materials management.

In many small-scale furniture manufacturing firms, all these materials management functions are performed single-handedly by the owner-manager, in addition to his other day-to-day tasks. The concern of materials management, in brief, is to fulfil the firm's needs for materials in the most economic manner, balancing all the factors involved, in order to obtain the most effective results. This includes the judicious purchase of the required materials; handling and accounting for them through temporary and final storage; and planning their movements through drying, stock preparation, assembling, finishing, packaging, warehousing and distribution.

Symptoms of poor materials management

Small-scale furniture manufacturing firms often experience problems resulting from poor or diffused control of the raw material input to the production operation. Some of these problems, which demand materials management-related solutions, are:

- Pilferage and other inventory losses;
- Failure to account for materials lost through the kiln or air drying of sawn timber;
- High materials cost relative to total production costs;
- Under-utilization of machinery and equipment;
- Considerable losses in direct labour time;
- Frequent delays in delivery;
- Too high an inventory of raw materials, semi-manufactures and finished products;
- Frequent running out of fast-moving stock;
- High obsolescence rates of basic raw materials;
- Congestion in manufacturing areas.

The purchasing function in materials management

The purchasing unit is responsible for buying the raw materials required. Specifically, it attempts to provide the firm with the required raw materials in the right quantity and quality, at the right time and price, and from the right source. In a typical small-scale furniture manufacturing firm, purchasing can function in a close-loop manner, as shown in figure 13. It involves the following phases: (1) Requisition from using department; (2) Selection of suppliers; (3) Issuance of orders; (4) Receipt of materials from suppliers; (5) Checking of suppliers' invoices; (6) Quality inspection of materials; (7) Issuing the materials to using department.

Figure 13. Basic purchase cycle

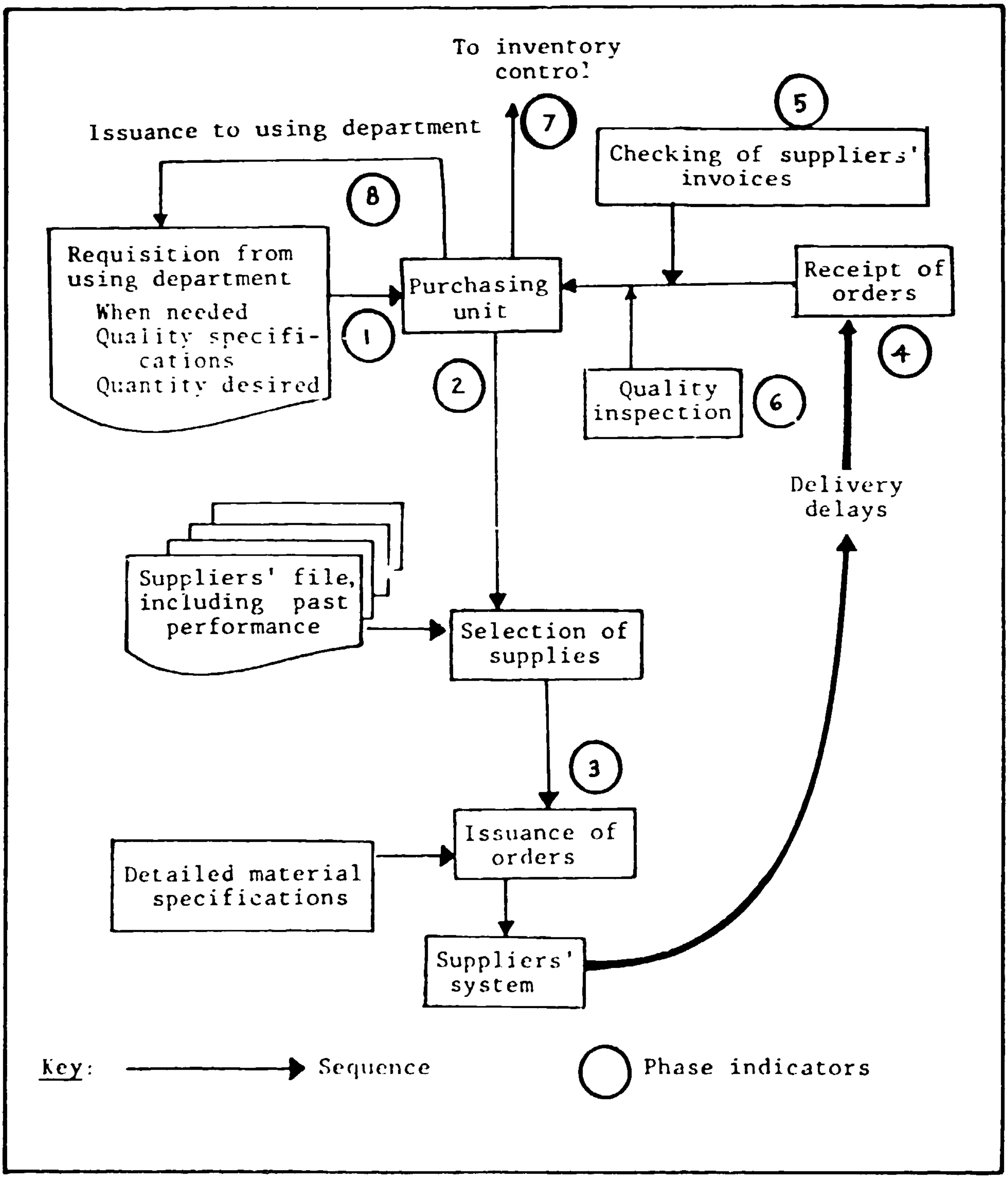


Figure 14. Forms used in the purchase cycle

A. Materials requisition form

Name of firm

____

____

Quantity	Unit	Description	Unit cost	Total cost

Remarks

Authorized signatures	Approved for production	Materials received by:
Dates Sales ______ ____ Designer ______ ____ Shop ______ ____ Production manager ______ ____	______________ Date ______________ Approved for delivery ______________ Date ______________	______________ Date ______________

B. Purchase order[a/]

Name of firm

____

____

Requisition No.
Purchase Order No.

To: ______________________
____
____

Date of issue: ______________
Date of delivery: ______________
Terms: ______________

Please deliver the following items according to the specifications detailed below:

Item No.	Quantity	Units	Particulars	Unit price	Total amount	Other

IMPORTANT: Always indicate our P.O. Number in your invoice covering shipments and attach this purchase order to your bill covering this order to facilitate payment.

a/ The conditions of purchase, normally stipulated by the ordering firm, are usually placed on the back of the purchase order form. In some instances, other conditions (price escalation clauses etc.) may be included.

C. Stock card/materials ledger card

Name of firm

____

____

Stock No. _____ Description: ______________ Unit: ______________ Acct. No. ______________

RECEIVED						ISSUED					BALANCE		
Date	P.O. No.	Qty.	Unit cost	Amount	Req. No.	Date	Job No.	Qty.	Unit cost	Amount	Qty.	Unit cost	Amount

D. Finished products delivery receipt

Name of firm

____

____

Delivery receipt

Delivered to:

____

____

D.R. No. ______________

Date ______________

Quantity	Description	Unit price amount

Prepared by:

______________ Date ________

Checked by:

______________ Date ________

Delivered by:

____

Date ______________

Received the above items in good order and condition:

____
Signature

Date ______________

The basic purchasing cycle can be implemented in a small firm using certain forms for documentation and information processing. Normally, a department within the firm will indicate its supply needs in a stock requisition form or a purchase requisition form. The former is used for requisitioning materials that are in stock (i.e. when materials are regularly ordered and maintained in inventory). This form goes direct to the stores department and the requirements are met from there. The purchase requisition form (sometimes referred to as a non-stock requisition form) is used for obtaining materials that are not kept in stock (materials that are used only infrequently). This form generally calls for more detailed specifications of the materials needed. On the basis of these specifications, the stores department locates the appropriate suppliers and issues the necessary purchase orders.

Some of the forms used in the purchasing cycle are shown in figure 1. The purchase order (B) is the form used by the firm to specify to a potential supplier the raw materials needed. This is the interface between the suppliers and the firm. The stock card or materials ledger card (C) is used to monitor all transactions concerning specific materials in stock. The delivery receipt (D) is used to acknowledge receipt of the finished product.

The purchasing function must assure a continuous flow of raw materials from the right source. This is best achieved by keeping the following factors in mind when purchasing: (a) commercial availability of the material; (b) quantity requirements over a certain period of production time; (c) financial resources available; (d) space available (if materials are bulky); (e) the time factor involved; and (f) the type of the purchase, i.e. if it is a one-item or multiple-item purchase (one time purchase of a number of items from a single supplier).

Inventory control systems

The other important aspect of materials management is the control or regulation of the financial resources tied up in stocks of raw materials. This control, if properly applied, will help to regulate investments in raw materials while assuring that there is an optimum level of materials in stock for the effective implementation of production plans or meeting requirements for job orders on hand.

In the small-scale furniture manufacturing firm, the term inventory normally refers to those articles and supplies described below.

Raw materials. These undergo processing or reprocessing in order to become a "part" of the product. In a firm manufacturing reproductions of antique wooden cabinets and chests, for example, the raw materials would include plywood and sawnwood, varnish, sealers and packaging materials.

Purchased parts. These are procured to be a part of the product and do not require any form of reprocessing (e.g. hardware). The purchased parts inventory tends to be high in firms using the services of several subcontractors. As in the case of raw materials, purchased parts should also have a functional classification while in inventory.

Operating supplies. Sanding elements, oil and lubricants are examples of operating supplies. They are used indirectly in the processing of finished products, but are not seen in the finished product.

Tools. Jigs, fixtures, tool bits, patterns and full-sized models are examples of the tools needed to keep the machinery and equipment of the company in good operating condition.

Office equipment and supplies. These are needed for the efficient day-to-day administration of the firm.

Finished goods. The firm's products awaiting sale or delivery.

Parts of work-in-process. These include fabricated, sub-assembled or semi-manufactured parts in various stages of processing.

If it is to regulate investment in inventory, the purchasing arm of the firm should be guided by some form of inventory policy. This policy will normally relate to the way in which the firm responds to the following basic issues of inventory management:

(a) In terms of control, which items of the firm's inventory should the owner-manager concentrate on?

(b) What quantity of raw material "X" should be bought at the most economic prices?

(c) Assuming that the second question has been successfully dealt with, when should the first purchase of "X" be made...The second purchase, and so on?

These questions assume particular importance if the firm is approaching or has already attained the stage of rigid mass production. As discussed in chapter I, the small firms engaged in purely intermittent or job-order production need not maintain the high volume of inventory that is essential in rigid mass production. In an intermittent operation, the normal practice is to purchase the necessary raw materials when the job orders are on hand. Thus, only a relatively simple inventory control system is required. In light of this, the first basic issue (a) can be examined, using what may be termed "the ABC classification of materials".

First basic issue: classification

The ABC classification will help the owner-manager determine which are the few vital materials in his inventory that require his personal attention and which are the non-vital ones the control of which can be delegated to a trusted employee. Here, the use of the Pareto Principle is imperative. Vilfredo Pareto, an Italian economist, while studying welfare economics, postulated that in most cases, 20 per cent (the vital few) of the inputs tended to create 80 per cent of the outputs.[6]

In inventory management, this 20-80 principle can be applied to the ABC classification by answering the question: Which 20 per cent of all the raw materials carried in inventory absorb 80 per cent of the total investment in inventory? The mechanics of constructing an ABC classification are as follows:

1. A list is prepared of all raw materials in stock, with their corresponding use rates (volume required per unit time) and unit costs.

2. The total investment for each type of raw material is calculated by multiplying use rates by unit costs.

3. The percentage of the total investment represented by each type of raw material is computed.

4. The original list of materials is rearranged, in descending order of the materials' percentages of total investments.

5. The percentages in the list are ummulatively added until a sum of at least 80 per cent is reached. At this point, all the raw materials classified as absorbing 80 per cent of the total investment in inventory can be termed "A" items, meaning items with high use rates (fast moving or high volume) and high unit costs (high values).

6. Cumulation is continued until 95 per cent of the raw material investment has been attained. All raw materials within this category, excluding the 80 per cent "A" items, are referred to as "B" items. These tend to have medium use rates and unit costs.

7. The raw materials accounting for the remaining 5 per cent are referred to as "C" items. They tend to have low use rates and unit costs.

The following simple example may facilitate application of the ABC classification.

The Tropical Furniture Company is a hypothetical small-scale firm in a developing country manufacturing "antique" chests and cabinets. The raw materials it has been using since its inception include: wood, hardware, decorative materials (bone, semi-precious stones etc.), varnish, chemicals and packing. The wife of the owner-manager acted as materials manager for all types of material except wood. She also doubled as the firm's treasurer, paymaster, and chief clerk. One day, however, she complained that the management of the firm's hardware materials had become too taxing for her. Since the firm began to export products to the Middle East, some six months previously, the volume of hardware-related work had increased considerably. The owner-manager was in favour of hiring an additional stock clerk for the task, but his wife worried about delegating control of the hardware materials since they constituted approximately 25 per cent of all the materials in inventory.

A small-business consultant (industrial extension officer) called in to advise on the situation suggested use of the ABC classification to work out a step-by-step process for delegating control of the hardware materials. Together with the wife of the owner-manager, the consultant, using the form shown in figure 15, drew up a list of the 36 different hardware items in inventory. To this listing they applied steps 1-3 of the ABC classification process, as outlined above. They proceeded by rearranging the materials (first column) using the ranking obtained (last column) in descending order of magnitude. This led to the classification format shown in figure 16 which permitted the consultant and the wife of the owner to apply steps 4-7 above.

The ABC classification showed that only 7 of the total inventory of 36 hardware items accounted for 80 per cent of the total investment in hardware materials. These 7 items of hardware (Lazy Susans; catches; ball coasters; 5-in. strap hinges; 2x12 woodscrews; brass padlocks; and imported brass rods) were then classified as "A" items because even though they had relatively low usage rates their unit costs were generally high. The owner's wife decided that she would delegate these items last of all to a stock clerk. Of the remaining items, 13 could be classified as "B", and the other 16, which accounted for only 5 per cent of the total hardware investment, were classified as "C". The wife decided that these latter, which tended to have high usage rates but very low per unit costs, would be delegated first to the stock clerk. She also discovered, to her amazement, that some of the items she had intuitively worried about in the past were really only "C" items and need not have bothered her at all.

Figure 15. Listing raw materials for ABC classification

Description of materials[a]	Estimated usage rates/month	Unit cost	Total cost	Percentage of total	Ranking (based on Percentage of total)

a/ Materials are not listed in any particular order, except, perhaps by their nature (e.g. screws, hinges, sanding materials).

Figure 16. Raw materials listing rearranged for ABC classification

Rank	Rearranged raw material listing	Percentage of total, in descending order	Cumulative sum of percentage	Classification of materials using the ABC rule

Thus, the ABC classification helps to focus attention on inventory that really matters. It should be periodically updated, however, to keep abreast of the ever-changing times. In the example given above, the classification system was employed for only one set of materials, i.e. hardware materials. In the case of very small firms, all items, rather than segments, should perhaps be considered.

Second basic issue: the economic order

Following the orderly classification of raw materials, the second question arises: How much of raw material "X" should be purchased as economically as possible?

To answer this question, it is necessary to analyse the costs of various items, then the degree to which they can be controlled. In general, the costs involved in the purchasing transaction cover the price of material; procurement costs; and inventory carrying costs. (See figure 17).

The price of materials may be set aside for the moment as, in general, small-scale furniture manufacturing firms have little influence over the prices of their basic materials, owing to their relatively low consumption rates. Of first concern are purchasing costs that are internal to the firm. Figure 18 shows the behaviour of procurement and inventory carrying costs for varying levels of material quality. As may be seen, procurement costs per order tend to decrease as the volume of materials per order increases. The inventory carrying costs, on the other hand, tends to increase with the quantity of materials purchased. If the inventory carrying costs and the procurement costs at varying quantity levels are added, a "total incremental purchase cost" curve can be developed. This total cost does not include the price paid for raw materials. The lowest point in the curve represents the economic ordering cost (EOC) and the economic ordering quantity (EOQ). It may be observed that if less than the EOQ is ordered, the total incremental costs are relatively high, while if more than the EOQ is ordered, the costs are likewise high. This observation is useful to the small-scale furniture manufacturer as it provides him with a guide to determining economic levels of materials inventory. It can also be discerned that processing frequent orders and carrying excessive inventory are expensive.

Determining an economic order quantity for specific raw materials maintained in inventory can be accomplished by means of (a) a tabular method; or (b) a formula method. Application of these methods is best illustrated by a return to the hypothetical Tropical Furniture Manufacturing Company.

The wife of the owner-manager, in her role as materials manager, wanted to know how many pairs of 3-in. hinges she should purchase in order to attain cost economy. Her records told her that on average the firm required 10,000 pairs per year. With the aid of the extension officer and the firm's part-time accountant, she was able to establish that for every purchase (N) of this item the firm spent IC 20.00 ("International Currency"), irrespective of the volume ordered, and IC 0.20 per unit of material ordered in carrying costs.

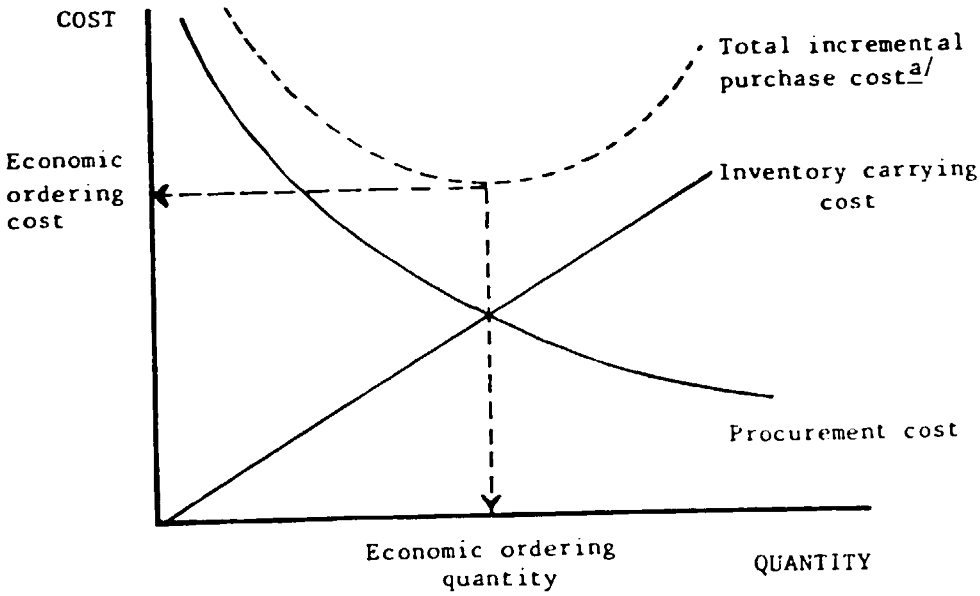
Thus, the annual material requirement (A) is 10,000 units. The procurement cost (P) is IC 20.00 per order. And the inventory carrying cost (C) is IC 0.20 per unit. The problem is first tackled using the tabular method.

Tabular method. This features a trial-and-error approach to determining economic order quantities. In the present example, the task is to determine the number of times the firm should order the materials, at the lowest cost, after inventory carrying and procurement costs have been considered. Here,

Figure 17. Costs involved in materials purchasing

Type of cost	Characteristic	Controllability	Units of measurement	Examples
Price	External to the firm	Uncontrollable where small firms are concerned	Monetary	-
Procurement cost	Fixed costs per order (internal)	Controllable	Monetary unit per order of material	Requisition costs Analysis and selection of orders Preparation of purchase orders Receiving of materials ordered Updating inventory records Inspecting materials Other paperwork
Inventory carrying costs	Variable costs per unit (internal)	Controllable	Monetary unit per piece of material	Taxes paid for materials ordered Interest expense Obsolescence Deterioration Shrinkage Insurance Shipping costs Handling

Figure 18. Procurement, inventory carrying and total incremental purchase costs



a/ The sum of inventory carrying costs and procurement costs for orders of various ordering quantities.

the tabular method proves to be a laborious exercise, however, as there are actually 10,000 options to choose from. One option is to order the 10,000 units required in one year one at a time, hence the number of ordering times (N) per year would be 10,000. The 10,000 units required for the entire year could be ordered only once, in which case N would equal 1. Each of these options have consequences in terms of purchasing costs.

This example of the tabular method may be further simplified by limiting the N options to only seven, i.e. order the annual requirement: (1) 20 times; (2) 15 times; (3) 10 times; (4) 5 times; (5) 3 times; (6) twice; and (7) once. Figure 19 shows the economic order quantities achieved by applying the tabular method to these options. The following notes are made concerning the figure:

Column A - This represents the firm's annual requirement of hinges - i.e. 10,000 pairs for any option considered.

Column N - This represents the ordering options considered. In practice, as many trials as possible should be carried out. These may range from N=1 to N=A. In the example given, the process has been simplified by assuming only seven options.

Column Q=A/N - This column indicates the quantity of hinges to be purchased per order.

Column PxN - This is the total procurement cost column. The procurement cost P=IC 20.00 does not vary with the number of orders. It will be observed, however, that the total procurement cost (P x N) tends to decrease as the quantity (Q=A/N) increases.

Column CxQ/2 - This is the column that defines the total cost of carrying the inventory. The values of CxQ/2 increase as the quantities per order increase. (This is further illustrated in figure 20.)

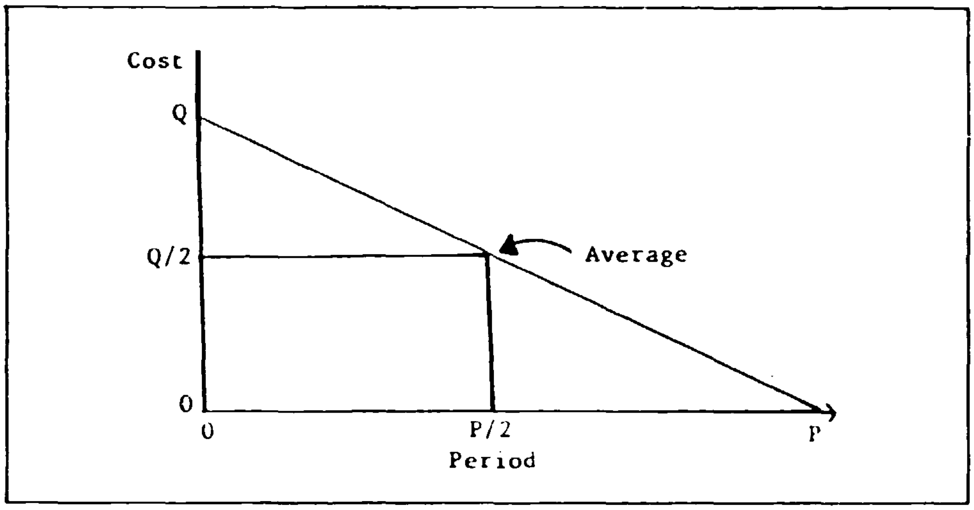
Column TIC - This column shows the total incremental cost, which is equal to the sum of the total procurement cost (PxN) and the total cost of carrying the inventory (CxQ/2). It serves as a gauge in determining the minimum unit purchase cost, after all other costs have been considered. The lowest figure determines the most economic order quantity (EOQ) and frequency (N).

Figure 19. Determining economic order quantities using the tabular method

A	N	$Q = A/N$	P x N	Q/2	C x Q/2	T I C	Remarks
10,000	20	500.00	400.00	250.00	50.00	450.00	
10,000	15	666.60	300.00	333.30	66.66	366.66	
10,000	10	1,000.00	200.00	500.00	100.00	300.00	Determining closer approximate minimum values
10,000	5	2,000.00	100.00	1,000.00	200.00	300.00	
10,000	3	3,333.30	60.00	1,666.60	333.33	393.33	
10,000	2	5,000.00	40.00	2,500.00	500.00	540.00	
10,000	1	10,000.00	20.00	5,000.00	1,000.00	1,020.00	

Note: Columns P x N, C x Q/2 and TIC are all expressed in International Currency (IC).

Figure 20. Behaviour of inventory carrying cost and inventory carrying period



Thus, in this particular example the economic order quantity lies between 1,000 and 2,000 units, the minimum being 1,430 units as the incremental cost of purchasing will be found to be at its minimum (IC 283.00) if the item is ordered 7 times per year.

Formula method. This is another simple and direct way of determining the economic order quantity (EOQ). The first step is to establish the relationship between the procurement costs and the inventory carrying costs at the economic order level. This relationship is depicted in figure 18, which shows that at the EOQ level the values of the two costs are equal. Hence, the relationship:

$$\text{Procurement cost} = \text{Inventory carrying cost} \qquad \text{Eq. 1}$$

Using the definition of the procurement and inventory carrying costs given in the tabular method, equation 1 can be rewritten as:

$$P \times N = C \times Q/2 \qquad \text{Eq. 2}$$

But the value of Q is A/N; substituting this value for Q in equation 2, will yield the following:

$$P \times N = C \times A/2N \qquad \text{Eq. 3}$$

The ordering frequency (N) is:

$$N = \sqrt{CA/2P} \qquad \text{Eq. 4}$$

The economic order quantity can now be found by using the relationship $Q = A/N$.

These equations may now be applied to the problem on hand, wherein it is known that:

A = 10,000 units

P = IC 20.00 per order

C = IC 0.20 per unit ordered

By substituting these values in equation 4, the value of N will be found to be

$$N = \sqrt{10{,}000 \times 0.20/(2 \times 20)} = \sqrt{50} = 7$$

Thus, the economic order quantity is found to be: 10,000 ÷ 7 = 1,429 units per order.

Before leaving the hypothetical Tropical Furniture Company, one further extension of the above arguments is worth considering. In this instance a hardware supplier has offered to sell the required hinges at IC 8.90 if the firm agrees to buy 1,600 units per purchase - as opposed to the IC 10.00 in the case of 1,429 units per purchase (the firm's EOQ level). Should the firm take this discounted price? The estimates of the relevant costs are outlined below:

Option 1. Buy at the EOQ level = 1,429 units per purchase.

	Amount (IC)
Total purchase cost at IC 10.00/unit	14,290.00
Procurement cost per order	20.00
Inventory carrying cost (IC 0.20/unit)	285.80
Total	14,595.80

Option 2. Buy at the discounted price. Discounted volume = 1,600 units per purchase

	Amount (IC)
Total purchase cost at IC 8.90/unit	14,240.00
Procurement cost per order	20.00
Inventory carrying cost (IC 0.20/unit)	320.00
Total	14,580.00

It is clear from the above that in the short run Tropical Furniture would benefit from the transaction. This case has been highly simplified, all cost items involved in procurement and inventory carrying having been assumed as being almost constant. In most cases, however, some cost items change with respect to the quantities ordered.

It will be observed from the foregoing that the formula method is simpler and more direct than the tabular method. It should be borne in mind, however, that the two methods are at best guidelines and should never be used as a substitute for experience.

Third basic issue: re-ordering

The questions of inventory classification and economic ordering having been dealt with, the final basic issue in inventory management concerns calculating the points at which to re-order. There are four principal factors involved in making this calculation:

1. Maximum inventory level. This is practically the equivalent to the economic order quantity, except that the minimum stock level is added to the economic order quantity.

2. Minimum inventory level. This is the reserve stock level. In general, this should be kept to the minimum.

3. Usage rate line. This is the average amount of materials consumed by the firm over a given period of time. For the purpose of the example given below, the usage rate is taken as constant, although in reality this is seldom the case.

4. Procurement lead time. This is the time involved in purchasing materials and parts - from the signing of the requisition slip to delivery into the firm's stockroom.

Figure 21 shows how the interrelationship of these factors influences the determination of re-order points. The first step in fixing these points is to estimate the usage rate of the materials. The usage rate line can be determined as follows:

$$\text{Usage rate} = \frac{\text{Maximum inventory level - Minimum inventory level}}{\text{Number of days needed to consume stock}}$$

Then, the re-order point is calculated, using the relationship shown below:

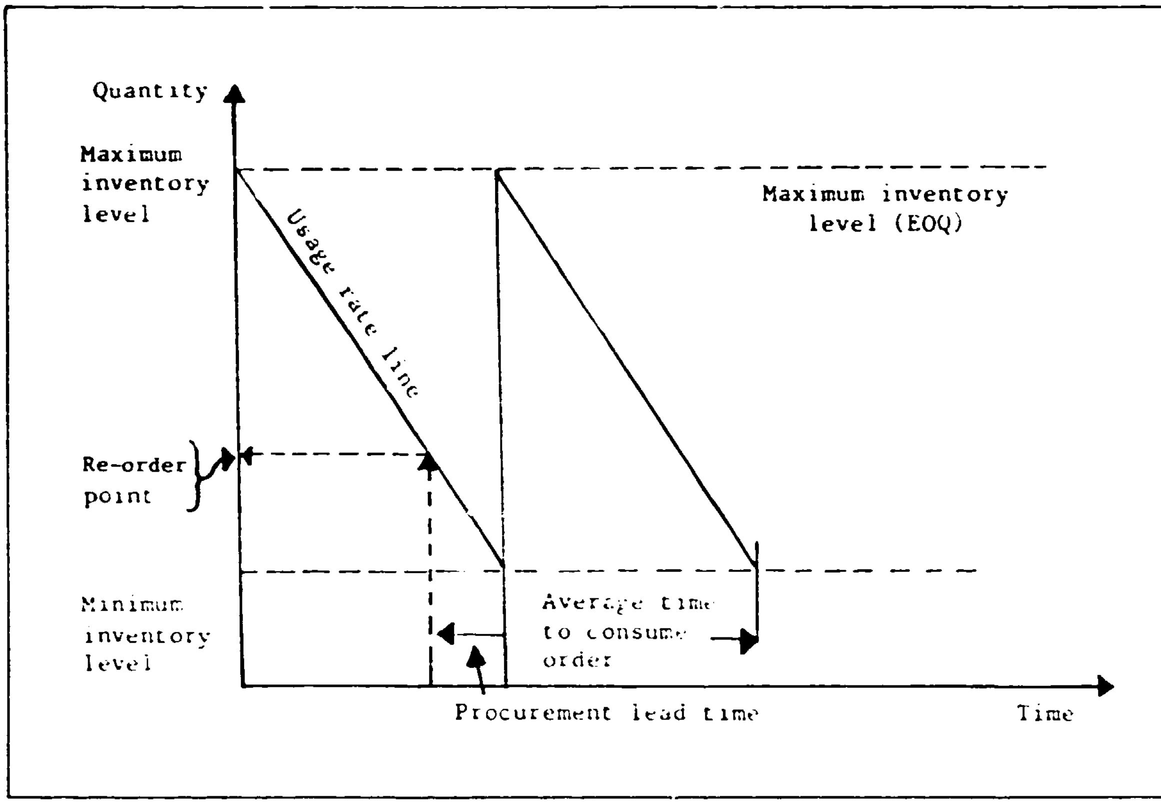
$$\text{Re-order point} = (\text{Usage rate} \times \text{Procurement lead time}) + \text{Minimum inventory level}$$

In practice, there are many variations to the concepts of economic orders and re-order points, two of which are:

- The two-bin system. The manufacturer procures raw materials in adequate quantities and stocks them in two-bin containers. When one bin has been emptied, it is time to re-order. The decision how much to buy and what volume bin to use may be based on the manufacturer's experience in the trade or on some form of estimate.

- The dollar-limit system. Another version of the two-bin system, this features the dollar value of the available raw materials as the purchasing indicator. A variation on this would be to use a quantitative instead of a monetary limit, as is common in the inventory control of wood materials in medium-sized firms.

Figure 21. Four factors in determining re-order points



<u>Designing an effective inventory control system</u>

Proper inventory control calls for the following steps to be taken:

(a) The performance of the existing stock monitoring system should be reviewed. This system should show at a glance what raw materials are in stock and the extent to which they will cover future production. In all situations involving raw materials purchasing, it is vital to know what is on hand. The stock monitoring system can best be reviewed by focusing on keeping the information contained in the stock cards accurate and up-to-date.

(b) A functional materials classification system should be established. This will facilitate sorting all the raw materials in stock:

- By type. (Wood, hardware etc.)
- By movement. (Fast or slow moving, based on usage rates.)
- By investment. (The ABC classification.)

(c) "A" items should generally be ordered for specific production runs, basing the size of the order on the quantity needed (i) for the production run and (ii) to maintain the minimum inventory level required. Here the EOQ levels will serve as a guide. It should be borne in mind that the primary objective is to cut down on inventories of these items (e.g. through motivating suppliers to stock the materials for the firm).

(d) "B" items should be subject to a "dollar" or similar type re-order system. The key element here is the accuracy and currency of the information contained in the stock cards. The purchase of certain "B" items from a single supplier is an idea also worth considering.

(e) Re-order limits for "C" items should be established on the basis of double the normal safety stock, since these items add little to the total cost of the inventory. Paperwork costs related to "C" items should be kept as low as possible.

IV. QUALITY MANAGEMENT AND CONTROL

To provide a glimpse of the quality management and control carried out in small-scale furniture manufacturing firms in developing countries, the owner-managers of two typical firms (A and B) were interviewed regarding their practices.

Company A. This company, which was started up in 1975, produces mainly hand-carved mahogany doors for local and export markets. It also manufactures plain-panel doors, jambs, lattice work, and wooden pieces (e.g. tiles) for the construction trade. All incoming wood materials are inspected visually for quality, and using an electric moisture meter. Defective materials are returned to the suppliers. Quality control is also employed throughout the manufacturing process. At each work station the machine operator involved inspects all materials reaching him. Finished products are inspected at the assembly area, after final sanding, by either the foreman or the production manager. Major defects seldom occur. Minor defects reported by customers can usually be remedied without affecting the firm's image with respect to the quality of its products. Customers are guaranteed free repair over a certain period of time. Moreover, products that don't conform to the customer's specifications may be returned.

Company B. This company manufactures tables, desks, upholstered chairs, cabinets and shelves on a job order basis for institutional buyers. Raw materials and finished products are inspected visually. Quality control in the manufacturing process is informally delegated to the workers involved. One of the duties of the production manager is to check the quality of incoming materials. Wood is meticulously inspected for the number, size and distribution of knots; end splits; rot and other faults; colour or shade; grain structure; and physical dimensions. No precise definitions of "defective" raw materials are used, as variations are quite natural and cannot be avoided. In any event, if "defects" are found in incoming materials, the materials can be returned to the supplier or used to bargain for lower prices. Inspection of finished products involves checking for variations in shade (i.e. in the application of colour coating) and smoothness of surface. The company believes that experienced carpenters can be relied upon to turn out a quality product, and underscores this belief by insisting that it hasn't disappointed any of its customers so far.

The following flaws are immediately apparent in the quality management and control practices described above.

1. Responsibility for quality control in the assembly area in both companies is vested in the machine operators or workers. Unless the management of the companies take it upon themselves to learn from their workers what constitutes "quality" in their own products, they will always be at a loss when workers decide to look for better jobs.

2. Both firms' definition of quality is vague. They seem to operate according to a rule that states: "I know a high quality piece of furniture when I see one". Although this rule may be sufficient when a firm is just starting, as time goes by it becomes necessary to evolve a definition of quality. This will not only make the firm's quality control practice precise, but also provides a definition that can be used in marketing the products more aggressively

3. Company A uses a moisture tester on its raw materials but does not document the quality performance of the suppliers of those materials.

4. Both companies accept the need to do repair work on their finished products; obviously, they have not recognized that this involves unnecessary costs.

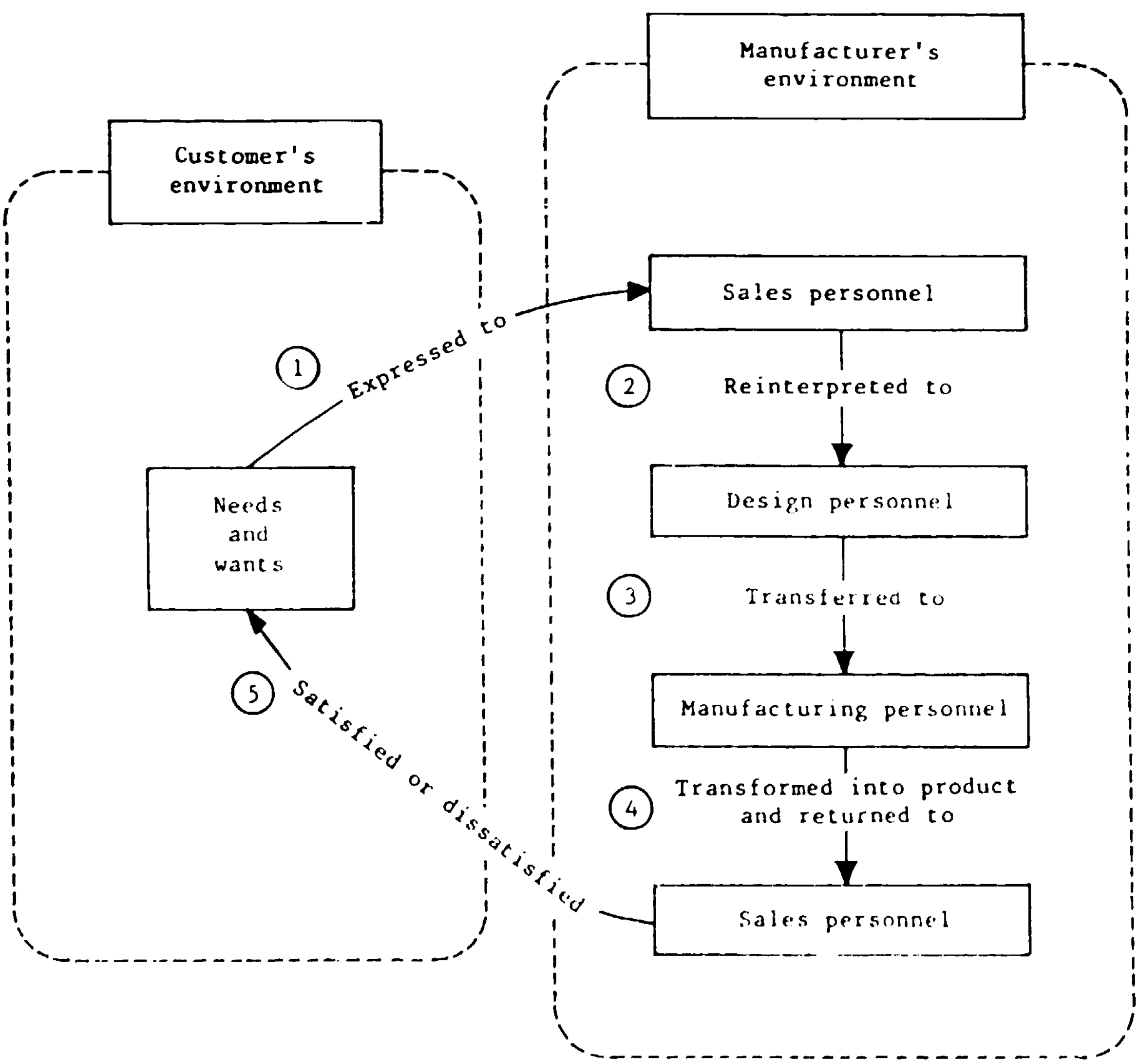
5. Both firms have established certain quality control points, e.g. production managers for incoming materials, machine operators in the assembly area, general manager for the finished products. This diffusion of quality control may prove ineffective unless the firm has its own definition of quality, evolved in the light of the market aimed at.

Specifications of quality

Where small-scale furniture manufacturing plants are concerned, "quality" is viewed in many ways. One is from the point of view of the manufacturer: "I'll produce whatever I think is best for my client". Another is from the point of view of the customer: "Manufacturers should produce the product in this manner, because we like it this way". Since, however, the definition of quality emanates from the customer, and is then refined or reinterpreted by the manufacturer, there is a strong argument for viewing quality from the customer's angle.

Figure 22 shows a general pattern of how quality definitions emerge.

Figure 22. How quality definitions emerge



From the diagram it will be noted that the definition of quality centres around the physical properties of the products that conform to or match the requirements of the customers. This definition must never be confused, however, with that of "perfect products". It is important for the small-scale manufacturer to evolve a definition of quality for his products since this will also serve as a measure of how closely he knows his target buyers. In evolving this definition, consideration must be given to the physical characteristics of furniture products which are directly measurable (length, width, thickness, rigidity, elasticity, strength etc.) as well as to those attributes which are less easily measured (beauty, smoothness, appeal etc.).

How quality standards emerge

There are two basic ways through which definitions (hence standards) of product quality emerge. One is when the manufacturer is asked to conform to a certain set of standards, e.g. when operations are geared to export markets, or when the company is a part subcontractor for a larger firm. The other way is when the firm, in time, evolves its own standards, having made it a point to minimize variations in the finished products.

Contact with customers gives the owner-manager an opportunity to define, in terms of quality, their needs and wishes. This definition will become more and more precise as the number of customers, and hence the degree of contact, increases. Naturally, the system of checking of raw materials, sub-assemblies and finished products will also benefit from this approach. In measuring dimensions for example, at the early stages, tape rulers with a millimetre scale may be used; then, after (say) two years, vernier calipers (reading by steps of 1/10 mm or 1/20 mm) may gradually be introduced, and so on. One way to ensure the evolution of the quality definition is to use a checklist covering those items that the operators should check at various stages of the manufacturing operation. Initially - when confined to checking incoming wood materials - the checklist may contain as little as 10 items. As experience grows, however, this number will gradually increase to (say) 25 over a two-year period. This process of correcting and improving, together with involvement with the target buyers, will ensure that quality standards develop as experience is gained.

Quality of design and conformance

Other aspects of quality are quality of design and quality of conformance. The former is concerned with deciding which product design will most satisfy the customer, while the latter implies a continuing process of measuring, testing and adjusting to ensure maintenance of the quality level stipulated at the design stage. Both aspects are important to firms employing the rigid type of mass production.

Quality control systems

Quality control means identifying causes of variations from set standards or specifications and correcting any defects resulting therefrom. Every quality control initiative should be both preventive and remedial in objective. Prevention is concerned with determining at various production stages the reason why defects occur, in order to keep them to a minimum at the final stage of production. The remedial aspect involves sorting out the defectives at the final stage, to ensure that only acceptable products reach the customer. A common way to ensure quality is to conduct inspections at various points in the manufacturing process. These inspections, which should feature the application of tests and the use of measuring devices to compare products and performance with specified standards, will facilitate the identification of defective products.

The procedures outlined in figure 23 may be found useful in controlling quality. The first step involves deciding on the standards to be adopted. These should be decided between the manufacturer and the customer, with both sides concentrating on the "trade-offs" involved: in other words, they should compromise or meet mid-way. If the manufacturer gives in too much to the wishes of the customer, the final product may turn out to be more expensive and take a longer time to produce than was anticipated. If, on the other hand, the customer accepts too many of the changes suggested by the entrepreneur, the product may turn out to be inappropriate to his needs.

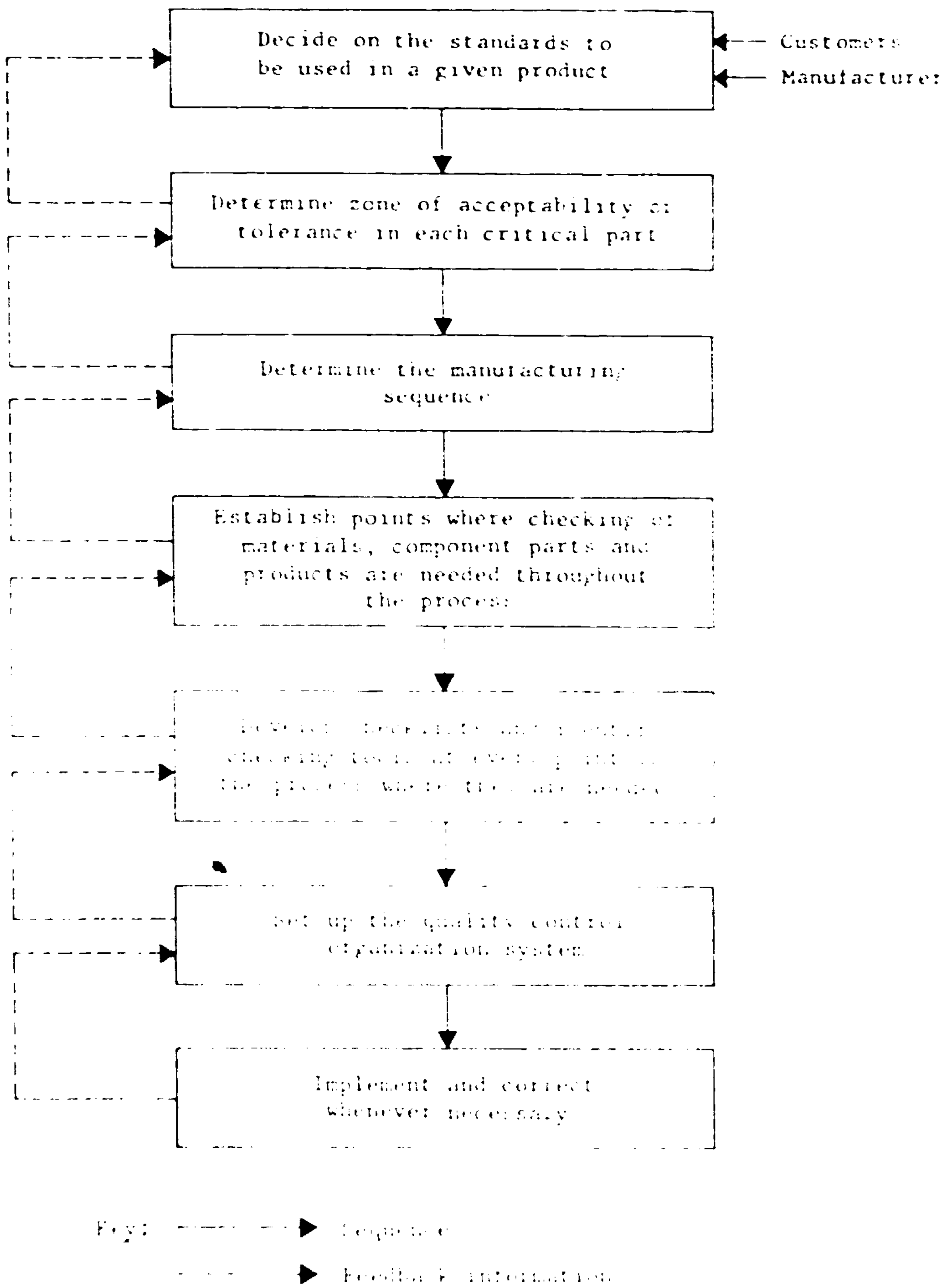
Determining the level of acceptability or tolerance is the second step. Here, the manufacturer is concerned with permissible variations in the basic criteria agreed upon at the first step. Again, in the furniture manufacturing industry, this is expressed in terms of the basic criterion plus or minus an acceptable tolerance limit; for example, the length of part "X" should be 2.000 ± 0.004 m. Tolerance limits should be broad enough to accommodate "chance variations" or variations caused by factors inherent in the production processes.

The next step is to determine the manufacturing sequence. (This procedure is also followed at the production planning phase where the necessary processes, machinery, equipment and workers are decided upon.) From this sequence, the manufacturer should be able to establish, with the aid of the customer, those critical points where quality standards should be strictly adhered to. These will constitute checkpoints where inspections will be made to ensure conformity with standards.

The next step involves listing the procedures to be followed by workers or inspectors in checking adherence to the quality level established at the first step. The tools or "hardware" used for inspection checks in a small-scale furniture manufacturing firm will include rules, calipers, straight-edge rulers, fixed and angle gauges, thickness gauges, snap gauges, "go/no-go" gauges etc. Normal inspection routines include: "first product inspection"; "random sampling"; "inspection by batch"; and "inspection of all products".

Finally, the inspection system must be activated. At this stage, the manufacturer should ask questions like: "Who is responsible for ensuring the quality of raw materials used?" "Who is responsible for checking at the first, second, and third critical points in the process?" and "Who will check the final products?" Once these and similar questions have been satisfactorily answered, the system can be implemented, the proper corrections and adjustments being made when and where necessary.

Figure 13. Quality control procedures for small-scale furniture manufacturing firms



V. METHODS ENGINEERING IN SMALL-SCALE FURNITURE MANUFACTURING

Low productivity

Low productivity is by far the most common production management problem confronting small-scale furniture manufacturing firms in developing countries. Following a visit to a typical household furniture manufacturer, an industrial extension officer filed the observations set out below.

(a) The machining section needs to be laid out anew, since the moulding machine is 28 metres from the finishing area. Modifying the layout would reduce the distance travelled by workers and raw materials. In general, the distances travelled by materials (manually hauled by skilled workers or machine operators) are unnecessarily long, owing to the lack of logic in the layout of machinery.

(b) In the fabrication of door panels (one of the firm's products), two cutting operations are performed, owing to lack of thorough inspection at the first cutting. This contributes much to delays in production schedules, especially at times when the firm has many job orders pending.

(c) The firm minimizes raw materials wastage by using off-cuts in the manufacture of wooden tiles, toys and the like. Wastage generated by the radial arm saw is about one inch; at the table saw, it is about one-half inch.

(d) On average, only 27 per cent of the available machine time is used productively; 6 per cent is used for indirect productive activities; 15 per cent for what could be classified as non-productive activities; and the remaining 54 per cent of the time the machines are idle.

(e) The 30 workers and machine operators spend 24 per cent of their time in direct productive activities; 25 per cent in indirect productive activities; 5 per cent in non-productive activities; and 46 per cent idle.

(f) The total working area is approximately 670 m^2, of which an area of 90 m^2, or 13 per cent, is not utilized.

Low productivity, although the most common problem facing small-scale furniture manufacturing firms, is also the least understood. When problems are traced to low productivity, it is immediately presumed that increased profits will come from co-ordinated and sustained efforts to increase the operating efficiency of the entire firm. Worse still, it may be considered that the solution to all the firm's troubles lies simply in increased activity (increased sales volume, expanded product lines etc.). This approach may succeed, or it may not. Some firms have substantially increased production only to discover later that such increase has not automatically brought about lower costs. This is normal: lower costs never come about by themselves. If a small firm is tuned to operate economically at a certain level of production, a sudden increase in output may bring into play so many unanticipated and expensive factors that the expenditure involved will far outweigh the savings resulting from the increased volume.

Nowadays, small-scale furniture manufacturing firms are concerned not only about increasing manufacturing costs, they are also discovering that customers are demanding higher standards of quality than ever before. Buyers are becoming more critical. They examine every product to make sure they are getting the greatest possible value for their money. As a rule, therefore, yesterday's quality standards will not do today.

It will be recalled that in chapter I the furniture production system was likened to a "black box", which essentially converts a set of inputs into a set of outputs. If the inputs and outputs of a firm can be qualified and reduced to terms of a single unit, then it will be possible to determine the efficiency of the conversion process. As this efficiency rating is synonymous with productivity, the overall productivity of the firm can be determined, using the following relationship:

$$\text{Productivity (expressed in percentages)} = \frac{\text{Output}}{\text{Input}} \times 100$$

Improvements in productivity, then, may be described as the use of fewer and fewer inputs to generate more and more outputs for more and more customers.

The process of systematically improving the productivity level of a firm is not new. It is embodied in a discipline variously referred to as "work study", "industrial engineering" or "time and motion study". This discipline is used in investigating human work in all its contexts and leads systematically to the identification of factors affecting efficiency and economy in a given situation with a view to bringing about improvements in that situation.

Work study is a valuable productivity improvement tool primarily because of the systematic approach used in investigating problems and developing solutions. Its employment requires that all relevant facts be available in order to ensure that suggested alterations in procedure will be based on accurate information. Where human activities are involved, there has always been a tendency to accept opinion in place of fact, with the result that decisions are often based upon what is believed to be true, rather than what is known to be true. The function of work study is to identify facts that will explain low productivity, and on this basis to point to various means of affecting improvement. Work study, in short, is an effort to replace guesswork by facts.

Work study procedures

Although work study covers a wide field - dealing as it does with such basic questions about work processes as "How should a particular job be done?", "How long should it take?" and "How much is it worth?" - it generally follows a five-step pattern, viz:

(a) Selecting an important job to study. This first step requires weighing the complexity of performing the work study and the potential improvement in productivity. Perhaps in the short run, the concern will be to do "old" jobs better, but in the long run, the focus should be on doing "new" jobs better, where improvements may be more marked. To provide a general guide, all aspects of the manufacturing operation that waste time, energy, materials, manpower, space, or machine time should be thoroughly scrutinized. The workers should be involved in choosing the area to study. This will minimize potential resistance to eventual change. In this respect:

(i) All workers should understand the purposes and objectives of the study and be aware of the benefits that may be derived from it, such as lighter workloads and enhanced safety;

(ii) The workers should be allowed to do most of the talking when the choice is being made, and the importance of their contribution to the potential success of the exercise should be emphasized;

(iii) The workers should be encouraged to suggest changes themselves. Experience shows that changes originating from workers' suggestions tend to be sustainable over the long run;

(iv) The ideas put forward by the workers should not be criticized at this stage. It must be borne in mind that the goal is to generate facts, not to criticize or to correct flaws.

(b) Breaking down the job and recording the details. This is a highly important step as the appropriateness and accuracy achieved in recording what is taking place on the job determine the success of the whole procedure. The results of this step provide the basis for subsequent steps, i.e. the critical examination of existing methods and the development of new ones. Recording techniques - which may include the use of charts, diagrams, models and sometimes even photographic aids - vary according to the nature of the activity being studied and the objectives of the study. As the more detailed techniques call for expenditure of considerable time and effort on the part of the owner-manager, and perhaps the industrial extension officer, they should be employed only when the return expected indicates their use to be justified.

(c) Questioning every detail with an open mind. Once a thorough and detailed recording of a particular manufacturing activity is available, a critical examination of the present way of working may be initiated. This examination is the crux of the entire work study procedure and should take the form of a systematic analysis of the nature, purpose, place, sequence, personnel, and the means involved in every step of the operation. At this stage, logical and satisfactory answers to the following questions should be sought:

(i) What is done, and why is it done?

(ii) When is it done, and why at this time?

(iii) Where is it done, and why at this particular place?

(iv) Who does it, and why that particular person?

(v) How is it done, and why in that manner?

(d) Generating the improvements. The detailed questioning continues at this step. Improving on the existing situation will require the application of a good deal of ingenuity, imagination and logical thinking in dealing with the following questions:

(i) What else can be done, and what should be done?

(ii) At what other time can it be done, and when should it be done?

(iii) Where else can it be done, and where should it be done?

(iv) Who else can do it, and who should do it?

(v) How else can it be done, and how should it be done?

The answers to these questions will lead to the selection of the best method of dealing with the situation.

(e) Introducing improvement. This is the final step, after an improved method of doing a particular task has been developed. At this stage, the most important factor in the work study exercise is to enlist the whole-hearted participation of all the employees concerned. Only their complete understanding of, and full co-operation in implementing, the proposed changes will ensure the long-term success of the improved methods. A negative attitude on the part of the workers is a deterrent that must be overcome if the positive results of the work study initiative are to be harvested.

The work study should preferably be conducted by a qualified industrial engineer. If the firm cannot afford to hire an engineer, the assistance of an industrial extension officer might be sought. The important thing is for the owner-manager to have an "eye" for the low productivity situation in his firm and the proper attitude towards dealing with it. Work study training programmes are available in most developing countries. The owner-manager should take advantage of them. His foreman or chief supervisor could also benefit from them.

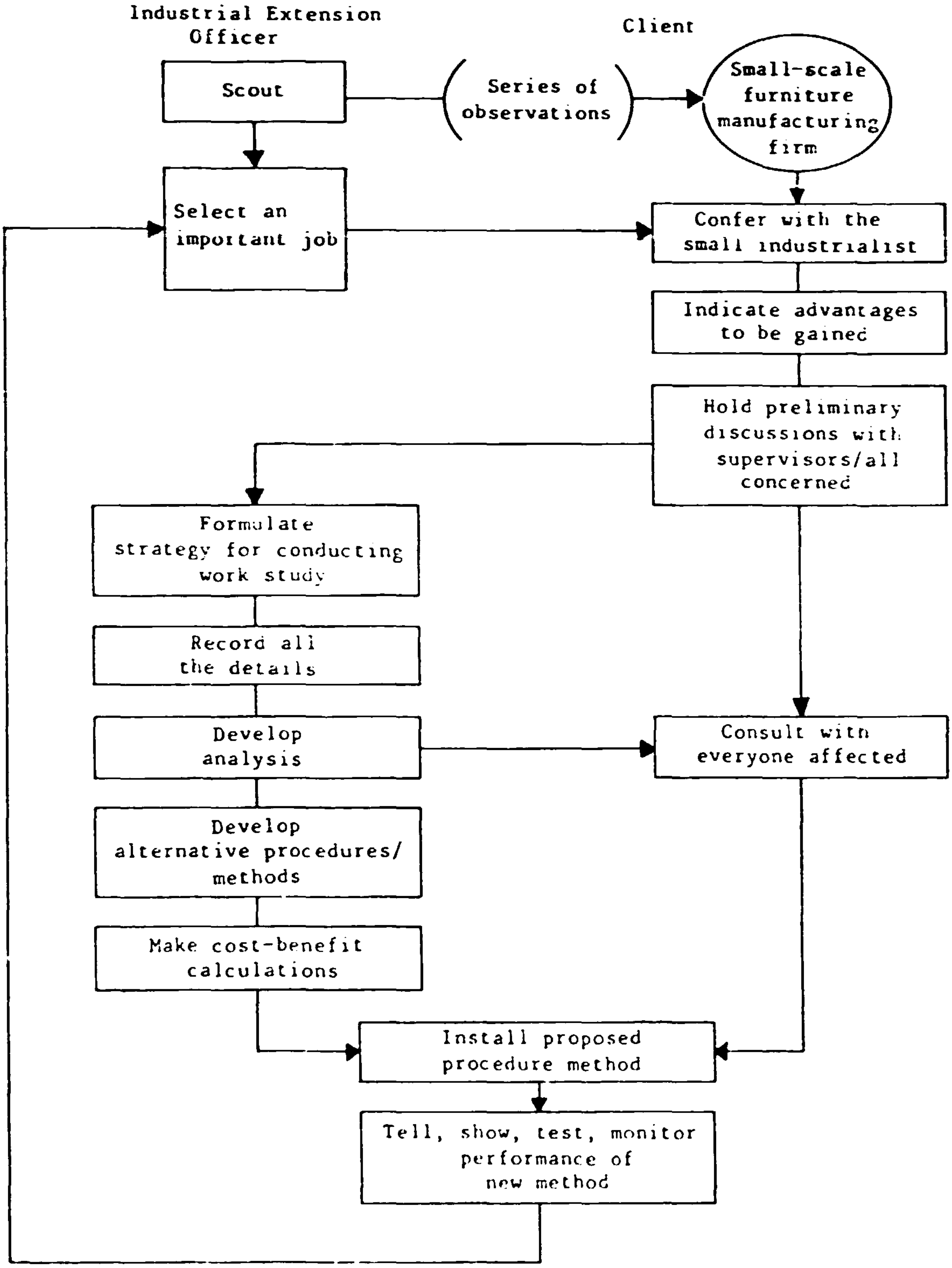
If an industrial extension officer is called in, the owner-manager as well as the officer concerned should remember that there are certain difficulties to be overcome at the initial stages of the work study. Valuable time and goodwill can evaporate unless the proper spirit and attitude are generated at the introductory stage. The level and range of difficulties will vary according to the size of the firm. The larger the firm, the more complicated its structure is likely to be, and the more staff grades and departments will be affected by the introduction of something new. The various categories of managerial personnel have vested interests of their own and are often disinclined for change. The establishment of a new section - say an industrial engineering section - may be viewed with suspicion or as an encroachment on the prerogatives of their own departments. The industrial extension officer selected must therefore have tact and understanding.

The workers will also probably have doubts concerning work study, particularly if the existing worker-management relationship is poor or if the firm has a sorry history in terms of employment and prosperity. The worker will want to know not only how work study operates but why it is necessary at all. It must also be remembered that although a trade union leadership (or the leadership of any informal organization exercising a like function) may have given full support to the objective of higher productivity and the means of achieving it, this does not guarantee complete acceptance by individual members of the union.

When the introduction of work study is being contemplated, every effort should be made to prevent incorrect rumours being circulated. Initial discussions should be confidential, and factual information given out as early as possible to all concerned.

The owner-manager must endeavour to anticipate the difficulties that may arise and seek to determine how work study can best be fitted into the existing organizational structure. The approach to be taken to the workers should also be considered in advance. There is no rule-of-thumb procedure for dealing with this, as it will vary considerably with different trades and firms. Two points are of paramount importance: (a) middle management and workers should be approached simultaneously, and (b) patience will be required in dealing with both groups. It may be necessary to hold a series of meetings with all parties concerned, in advance of the work study, in order that prejudices and doubts may be reduced to a minimum before a start is made. A systematic way of introducing the work study concept into a small-scale furniture manufacturing firm, using an industrial extension officer, is depicted in figure 24.

Figure 24. Introducing the work study concept through an industrial extension officer



Methods engineering

Methods engineering is one of the two major branches of work study. The other is work measurement, which is the subject of the next chapter. Methods engineering applied to a furniture manufacturing firm improves working methods by economizing on movement of materials and workers. It enhances the utilization of machines, equipment, land and buildings, and - if coupled with value analysis - can bring about improvements in design. Methods engineering attempts to minimize the unnecessary work that may be due to any or a combination of the following:

(a) Poor product design. As mentioned earlier, the small-scale furniture manufacturer has the right to try to "sell" his own ideas to customers in the process of specifying a product's dimensions and other features. He may attempt to persuade the customer of the savings he can make by agreeing to some of his suggestions. The process of specifying quality requirements, it must be remembered, is a compromise between the customer's needs and the manufacturer's capabilities. Product designs and specifications that lead to increased manufacturing time normally feature:

(i) Poor product design, which prevents the use of economical processes and leads to excessive use of materials;

(ii) Lack of standardization, which prevents the use of more sophisticated production processes;

(iii) Incorrect quality standards, which cause unnecessary reworks.

(b) Inefficient methods and processes. Furniture manufacturing technology, like other technologies, offers a host of options in manufacturing, including options with respect to the methods, tools, jigs, fixtures and machines to be used. Employing inappropriate methods and tools normally leads to unnecessary work. In some instances, processes are not performed correctly or suffer because machines are in bad condition, i.e. tolerances cannot be enforced. Added to this, operators may also use bad methods of working.

Methods engineering in a small-scale furniture manufacturing firm follows the same pattern as work study. The main difference is in the recording techniques employed.

Tools of methods engineering

Generally speaking, the tools of methods engineering are embodied in the standardized format recording techniques used. Recordings are made in order to:

(a) Obtain a clearer picture of a given situation than that provided by written or verbal descriptions;

(b) Be able to verify the completeness of the data generated;

(c) Transfer data effectively in the shortest time possible. Experience proves that data presented in a familiar pattern is more easily assimilated;

(d) Provide an effective medium for comparison. In methods engineering, many types of situations relating to the "before" and "after" stages of improvement must be dealt with. For ease of comparison, a standardized format is essential. The principal methods engineering tools are: flow charts; process analysis charts; and multi-activity charts.

Flow charts

The manufacturing flow chart is the best as well as the simplest tool. Essentially, it is used to investigate the sequence of steps in the manufacture of a piece of furniture and to indicate action that should be taken to eliminate, combine or rearrange steps in order to attain the most economical method of operating. There are two types of flow chart: general and detailed.

The general flow chart shows a broad picture of all or some of the furniture manufacturing processes. Its usefulness stems from its ability to provide not only an overall picture of a process under review, but the various logical relationships existing between that process and other processes employed by the firm. Figure 25 is an example of a general flow chart for the preparation of solid wood components in a furniture manufacturing plant.

The detailed flow chart, as the name implies, entails greater detail in the recording process. A sign language is used to symbolize and generally classify all the tasks and activities of the workers.

The first symbol is a circle, and it is used to denote an operation such as sawing, routing, boring, drilling, sanding or finishing. It is used to indicate any action taken to increase the value of the raw materials. The raw materials may change with respect to their physical or mechanical (e.g. if they are laminated) characteristics, as required by the product specification.)

The second symbol is an arrow and is used to denote the transportation or movement of raw materials from one work station to another, or from one building to another. Essentially, the symbol indicates that the material has left one worker to be further worked on by another (this also represents a transfer of responsibility). It must be borne in mind that activities classified as transportation do not enhance the value of the furniture products and should therefore be minimized or eliminated.

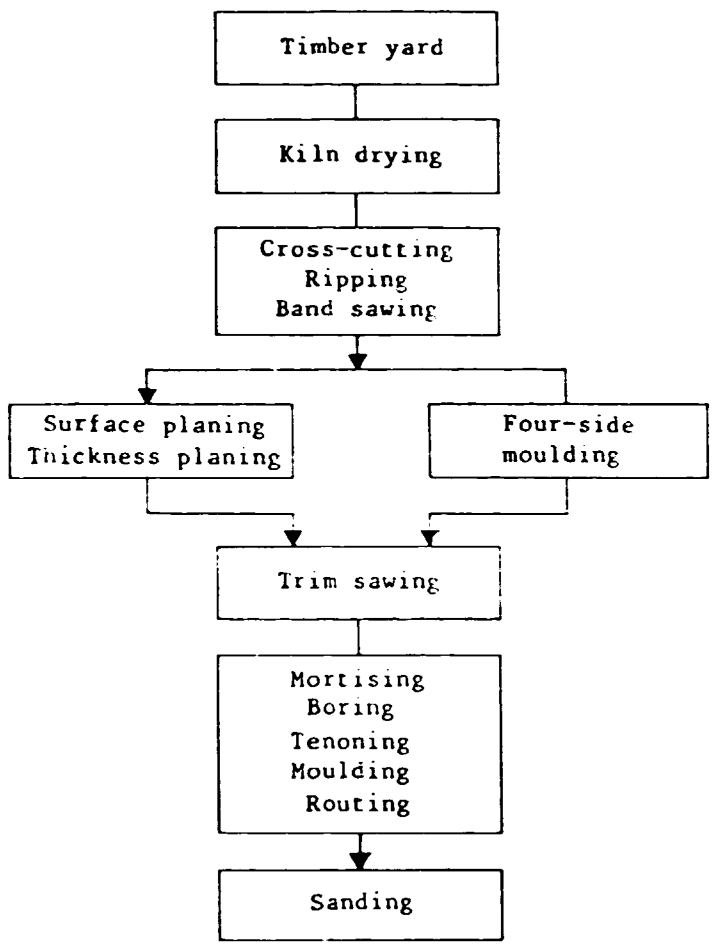
The third symbol, a square, denotes inspection of the materials. This is used for all tasks related to the examination or checking of work for quality, no matter whether it is performed by one worker or a group of workers.

The fourth symbol, the letter D, stands for temporary delay. In job-order manufacturing, there are usually more delays involved than in the rigid type of mass production. Although this symbol usually denotes a wait for raw materials, it may also indicate failure to accomplish a certain manufacturing activity.

The fifth symbol is the triangle. An inverted triangle denotes storage of raw materials; an upright one denotes storage of finished products.

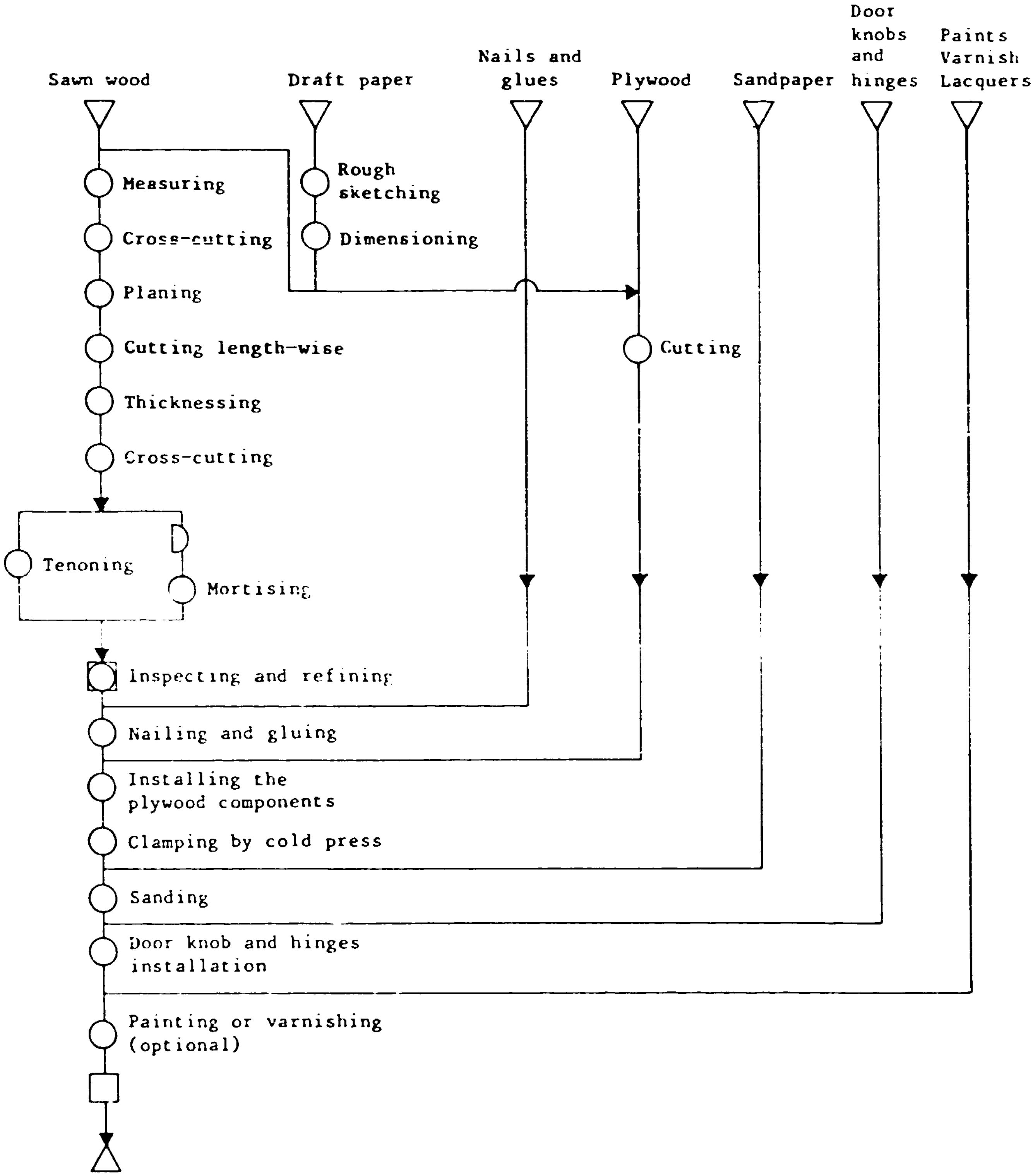
Figure 26 shows a detailed flow chart used by a small-scale plain-flush-door manufacturer in a developing country. There are two ways of dealing with the results of a detailed flow chart analysis: (a) the time spent on non-value-adding activities (transportation, delay, inspection, storage etc) can be eliminated or minimized, and (b) activities, which are value-adding through sub-contracting or other means, should be eliminated - which will also automatically eliminate "make-ready" and "put-away" activities. The occasion might also be used to combine, re-arrange or simplify some of the manufacturing operations.

Figure 25. General flow chart for the preparation of solid wood components



Source: P. Paavola, "Furniture technology", in Furniture and Joinery Industries for Developing Countries (ID/108/Rev. 1), p. 150.

Figure 26. Detailed flow chart of plain flush door manufacturing process



Process analysis chart

The necessity has been discussed of visualizing the furniture manufacturing operation in its entirety through the five basic activities (operation, delay, storage, inspection and transportation) of raw materials handling. Besides indicating the forms of improvement that might be generated, the flow charts also provide a guide as to which manufacturing process should be subject to "microscopic" investigation. The process analysis chart is used to perform such an investigation. In addition to classifying all the activities in the process under review, it provides information on the quantities of materials used, the time spent on each activity, and the distance traversed by the raw materials used - information that will be extremely useful in pinpointing the causes or symptoms of low productivity. Figure 27 is an example of a process analysis chart used in preparing the materials needed to manufacture flush-type wooden doors. The results of the analysis may be useful not only for improving existing situations but also for cost estimating, a critical element in job-order operations. By conducting a detailed study of the manufacturing operation, using the process analysis chart, the flow of materials (materials-type process analysis) or the movement of personnel (worker-type process analysis) can be traced with some degree of accuracy.

It may be desired to use the process analysis chart to concentrate on the activity of, say, an operator or an assembly worker. Perhaps the concern is to balance the workload between his right hand and his left. In this case, a variant of the process analysis chart - the right-hand and left-hand chart - is employed. See figure 28.

Multi-activity chart

Balancing the workload between the right and left hands can also be achieved using the multi-activity chart. This chart can depict the activities of more than one subject (e.g. workers, machinery, equipment, or the right and left hands) on a common time-scale in order to allow investigation of the dependency of their relationships. Primarily, it is designed to facilitate determination of ways to reduce idle time in both men and machines. To illustrate the use of the multi-activity chart, a highly simplified version of a common problem encountered in furniture manufacturing is presented below.

A circular-saw operator prepares the material for a feeding operation requiring, say, one minute. By the time he has arranged the material on the table of the circular saw, and made all the adjustments needed prior to cutting, another minute is gone. The cutting operation requires another minute. The worker then removes the materials - another minute - and another cycle begins.

At first impression, there is nothing wrong with the operator-saw relationship or dependency. Closer examination shows, however, that the saw is idle three quarters of the cycle time and that the operator is engaged in "make-ready" and "put-away" activities for the same length of time. This is illustrated in figure 29.

Figure 27. Process analysis chart

Process analysis chart - Materials type (Present)

Chart No. 1 Sheet No. 1 of 1

Subject charted: Door manufacturing (Flush-type wooden door)

Location: Main workshop

Operator:

Charted by: EQC

Date:

Summary

Functions	Present	Proposed	Savings
Operation	8		
Transport	8		
Delay	0		
Inspection	1		
Storage	1		
Distance	43.1 m		
Time	18 min 19 s		
Cost	Not available		
Totals	-		

No.	Description of activities	○	⇨	D	□	▽	Qty.	Dist.	Time	Remarks
1.	Raw material at the stock pile					●	-	-	-	
2.	Raw material (2"x6"x13') picked up		●				1	5.2 m	27 s	1 worker
3.	Cross-cutting of raw materials by radial-arm saw	●					1	0	4 s	one at a time
4.	Transport to planer		●				2	2.6 m	6 s	1 worker
5.	Planing of raw materials	●					-	0	55 s	1 worker
6.	Transport to tilting arbor saw		●				2	4.6 m	7 s	1 worker
7.	Cutting of raw material length-wise	●					0	0	1 min 10 s	1 worker
8.	Transport to next radial arm saw		●				6	5.2 m	10 s	1 worker
9.	Cross cut raw material into halves	●					0	0	1 min 10 s	1 worker
10.	Transport to thickness planer		●				10	3.5 m	15 s	1 worker
11.	Reduce thickness (from 2" to 1 1/2")	●					0	0	2 min 33 s	1 worker
12.	Transport back to radial arm saw		●				10	3.8 m	20 s	1 worker
13.	Cross cutting of semi-finished materials	●					0	0	20 s	1 worker
14.	Raw material - 7 pcs. 1 1/2" x 2" x 3', 4 pcs. 1 1/2" x 2" x 1', 2 pcs. 1 1/2" x 2" x 7'				●		13	-	1 min 0 s	1 worker
15.	Tenoning, using radial arm saw	●					7	-	2 min 10 s	1 worker
16.	Transport 2 pcs. of 1 1/2" x 2" x 7' to mortiser		●				2	9.9 m	25 s	1 worker
17.	Mortising of 2 pcs. (1 1/2" x 2" x 7'), 7 mortises each	●					2	-	6 min 40 s	1 worker
18.	Frame parts transport		●				13	8.3 m	22 s	1 worker
	Totals						-	43.1 m	18 min 14 s	

Figure 28. Right-hand and left-hand chart

Chart No. ____ Sheet No. ____ of ____ Drawing of assembly studied: ________ Subject of study: ________________ ______________________ Operator: ________________ Location: ________________ Charted by: ______ Date: ________	Workplace layout

Left-hand activities Description	Symbols					Symbols					Right-hand activities Description
	○	⇨	D	□	▽△	○	⇨	D	□	▽△	

Methods	Present		Proposed		Remarks
	L.H.	R.H.	L.H.	R.H.	
Operations					
Transports					
Delays					
Holding and storage					
Inspection					
Totals					

Figure 29. Example of use of a multi-activity chart

Operator	Time (minutes)	Circular saw
Obtaining the material for cutting	0	Idle
Arranging the material in the saw table prior to cutting	1	Occupied
Idle (material fed to saw)	2	Cutting
Putting cut materials away	3 4	Idle
End of one cycle		

Computing the values of the following further clarifies the operator-saw relationship.

1. Machine utilization (%) $= \dfrac{\text{Time spent on "do" activities} \times 100}{\text{Total cycle time}}$

2. Operator's utilization of the machine (%) $= \dfrac{\text{Time spent for "make-ready" and "put-away" activities} \times 100}{\text{Total cycle time}}$

In this example, cutting is the only "do" activity performed by the saw. The machine is in use, therefore, for a poor 25 per cent of the time (1 out of 4 minutes), while the operator spends 75 per cent of his time operating the machine (3 out of 4 minutes). There are two basic approaches to improving the man-machine relationship and thereby attaining greater economy and efficiency in the manufacturing operation:

(a) Some of the "make-ready" and "put-away" activities may be infused into the "do" elements for each cycle time. One way of accomplishing this in furniture manufacturing is by using low-cost automation.[7/]

(b) The operator may be asked to operate other similar machines, or given extra, but related, work to perform during the idle parts of the cycle.

Principles of methods engineering

Some general principles have been formulated that may be found useful in developing new methods or improving existing ones in furniture manufacturing operations. These principles govern motion economy; workplace layout and design; and materials handling.[8/]

Principles of motion economy

When possible, movements of the human body should be as follows:

		Codes[9/]
1.	The hands should begin and complete their movements at the same time.	B and C
2.	The hands should not be idle at the same time, except during periods of rest.	B and C
3.	Arm motions should be symmetrical, in opposite directions, and made simultaneously.	B and C
4.	Hand and body motions should be at the lowest classification [10/] needed to do the work satisfactorily.	A, B and C
5.	Momentum should be employed to help the worker, but must be reduced to a minimum whenever it has to be overcome by muscular effort.	B and C
6.	Rhythm is essential to the smooth and automatic performance of a repetitive operation. Work should be arranged to permit easy and natural rhythm whenever possible.	B and C
7.	Work should be arranged so that eye movements are confined to a comfortable area, without frequent changes of focus.	A, B and C

The work place should be arranged as follows:

1.	Fixed stations should be provided for all tools and materials, to encourage habit forming.	A, B and C
2.	Tools and materials should be placed in position prior to manufacture, in order to reduce time spent in searching for them.	B and C
3.	Gravity-feed bins and containers should be used to deliver the materials as close as possible to where they are needed.	B and C
4.	Tools, materials and controls should be located within or as near as possible to the working area.	A, B and C
5.	Materials and tools should be so arranged as to permit the optimum sequence of motions.	A, B and C
6.	"Drop delivers" or ejectors should be used whenever possible to reduce the need for the operative to use his hands to dispose of finished work.	C
7.	Lighting should be adequate. A chair that will permit good posture should be provided for the operative. The area of the work place should allow alternate standing and sitting.	A, B and C

8. The colour of the workplace should contrast with that of the work, to reduce eye fatigue. — A, B and C

The design of tools and equipment should be such that:

1. The hands may be relieved of the chore of holding the workpiece when this can be done by a jig, fixture or foot-operated device. — A, B and C

2. Two or more tools can be combined whenever possible. — A, B and C

3. Levers, crossbars and handwheels can be placed so that the operator can use them whilst making the least change in his body position, yet offering the greatest mechanical advantage. — B and C

Principles of workplace layout design

1. If similar work is being done by each hand, there should be a separate supply of materials or parts for each hand. — B and C

2. If the eyes are used in the selection of materials, the materials should be kept, to the extent possible, where the eyes can locate them without the worker turning his head. — C

3. The nature and shape of materials determines their position in the layout. — A, B and C

4. Tools should be easily picked up and replaced. As far as possible, they should have an automatic return, or the location of the next piece of materials to be moved should allow the tool to be returned as the hand travels to pick it up. — C

5. Finished work should be:

   (a) Dropped down a hole or a chute; — A and B

   (b) Dropped through a chute, when the hand is starting the first motion of the next cycle; — A and B

   (c) Put in a container so that hand movements can be kept to a minimum; — A and B

   (d) Placed in a container in such a way that the next operator can pick it up easily (if the operation is an intermediate one). — A, B and C

6. The possibility should always be examined of using pedals or knee-operated levers for locking or indexing devices on fixtures, or devices for disposing of finished work. — B and C

Principles of materials handling

1. Handling should be eliminated to the extent possible. When it is required, mechanical rather than human handling is to be preferred.	B and C
2. Handling should be combined with the work, inspection or other processes that would normally precede or follow it.	B and C
3. To minimize handling cost, work processes should include the use of as many hand tools and as much semi-automatic machinery as possible.	B and C
4. Materials handling facilities should be continuously updated.	A, B and C

Application of methods engineering

Methods engineering can be applied at practically all stages of furniture manufacturing. In product design and development, it can help bring into focus how each component part contributes to the desired end result.[11/] At the processing and assembly stages, it can serve as a potent tool for continually improving operations, as illustrated by the following case. A small-scale door manufacturing firm with 30 workers embarked on a company-wide methods improvement programme with the aid of an industrial extension officer. After almost a month of recording and analyzing the relevant facts, the firm decided to change its layout and introduce various improvements in selected flush-door manufacturing processes. The result was a 30 per cent increase in production and savings of IC 32.24 per door per day. With an approximate daily ouput of 24 doors, this meant a saving of IC 15,475 a month or IC 185,702 a year.

As soon as a firm embarks on a programme to improve its manufacturing operations and increase its productivity, it will observe that one improvement opens doors for others. When taking such initiatives, therefore, the possibility of effecting improvements in other areas should be borne in mind. It must be remembered also that there is always a better way of doing things. The task of the firm must be to constantly search, record and analyze, with a view to developing and introducing improved methods. In the long run, it will be found, this will be the firm's lever in sustaining its competitiveness in the marketplace.

VI. WORK MEASUREMENT: CONCEPTS AND PRACTICES IN SMALL-SCALE FURNITURE MANUFACTURING FIRMS

Scope of work measurement

The other aspect of work study is known as work measurement. This is generally concerned with the investigation and evaluation of all types of human work in an industrial setting. In more precise terms, work measurement techniques are used to gauge - in terms of time units - the work content of jobs performed by trained, qualified workers employing specific methods or procedures.

If the work content of a job could be measured in terms acceptable to both management and workers, then work measurement could make a substantial contribution towards determining what constitutes a "fair day's pay for a fair day's work" in various manufacturing activities. Unfortunately, however, many people, particularly those operating job-order furniture manufacturing firms and remunerating their workers on a piece-rate basis, believe that the sole purpose of work measurement is to improve the administration of the firm in terms of wages and incentives. In fact, having the work content measured in terms of time units for the critical - if not all - stages of manufacturing will increase the effectiveness of workload scheduling and distribution. Likewise, having work content information readily accessible will improve the firm's ability to estimate direct labour costs for every job or production batch.

Finally, work measurement is an extension of methods engineering. In this context, it is an aid in choosing alternative methods of performing a specific operation in the furniture manufacturing process. As reduction in the time needed to perform a task is the only valid proof of improved methods, the work measurement process must be sustained until a satisfactory method for doing a particular job has been developed. In the search for this method, the contribution that work measurement can make towards improving the overall productivity of the firm will become clear.

Work measurement and productivity improvement

Small firms in developing countries are often accused by their customers of failing to deliver as promised. In some cases, they are able to get by with this practice, but with today's consumers increasingly demanding value for their money, such firms will become uncompetitive in the long run. In the case of furniture firms, delayed deliveries may be due to (a) overly optimistic estimates of the production time required, and (b) low productivity on the part of management and workers.

Overly optimistic estimation of production time requirements is an information-related problem. This may mean that the owner-manager is unable to marshal, and effectively utilize, the experience acquired by the firm in its day-to-day business. To remedy this situation, promised delivery dates must be compared with actual delivery dates, and the factors responsible for discrepancies identified and eliminated. A programme should then be initiated aimed at reducing the delivery time by at least half. (This aspect is discussed further in chapter VIII.)

Low productivity on the part of management and workers will also result in delayed delivery. In chapter V, two factors were cited as being responsible for unnecessary increase in the basic work content: defective product design or specification, and inefficient methods of manufacture. Another factor, discussed below, is the time lost through inefficiency on the part of management and workers.

Examples of inefficient management in furniture manufacturing are:

(a) Offering too wide a variety of products, coupled with lack of, or inadequate, standardization initiatives. (This leads to short production runs and relatively longer set-up times.)

(b) Poor product specification at the job-order preparation stage. (This can lead to frequent design changes, which in turn cause stoppages in production.)

(c) Failure to properly co-ordinate the acquisition of material inputs. (This can lead to high incidence of machine, equipment and manpower idleness.)

(d) Poor maintenance. (This can lead to plant breakdown and costly repairs.)

(e) Inadequate safety measures. (Consequent absences of workers and work stoppages result in loss of production time.)

(f) Bad working conditions and conditions of work. (These result in foremen and the like spending increased time on purely supervisory work.)

Worker inefficiency is indicated by habitual absence, tardiness and idleness. Careless workmanship and a negative attitude likewise add unnecessary time to the basic work content.

Work measurement can help to minimize, if not to eliminate, some of the inefficiencies of management and workers. The keys to the successful application of work measurement are thoroughness, patience and honesty: thoroughness in considering every contingency; patience in searching for the relevant explanations of cause and effect; and honesty in using the results of the initiative.

Techniques of work measurement

Work measurement, when used to evaluate selected human activities in a firm, generally follows the work study process of selecting a job to study; breaking it down into its various components; recording every detail; and questioning every detail, keeping an open mind. There are several techniques that may be employed, and the choice will depend upon the objectives of the investigation. In the paragraphs that follow, two major objectives of work measurement are reviewed which reflect the concern of most small-scale furniture manufacturing firms in developing countries. These are: (a) the determination and quantification of non-productive activities; and (b) the determination of standard times needed to perform selected furniture manufacturing activities, as the basis for costing and incentive schemes.

Ratio delay study is a technique used to identify and quantify productive and non-productive activities in a firm. It involves a considerable number of spot observations being made over a period of time for a group of workers, machines and equipment. Each observation records what is happening at a particular instant. The frequencies of occurrence of the various productive and non-productive activities are captured and expressed as percentages of the actual production time.

Time study is concerned with assessing - in terms of time units - the value or content of work performed through human effort. The technique is used to determine the "standard" times needed for selected, common furniture manufacturing processes. The standard time is the time required by a qualified (experienced, trained or both) worker to perform a given operation, using a specified method or procedure and working at normal tempo. The standard times thus derived are useful in estimating direct labour costs and introducing incentive schemes.

Ratio delay studies

Neither the concept of, nor the procedures used in, ratio delay studies are new. Their application in small-scale furniture manufacturing firms in developing countries would, however, be relatively new, and are certainly desirable. At this point, two basic questions should be answered: (a) Who shall conduct the ratio delay studies? and (b) How should they be conducted?

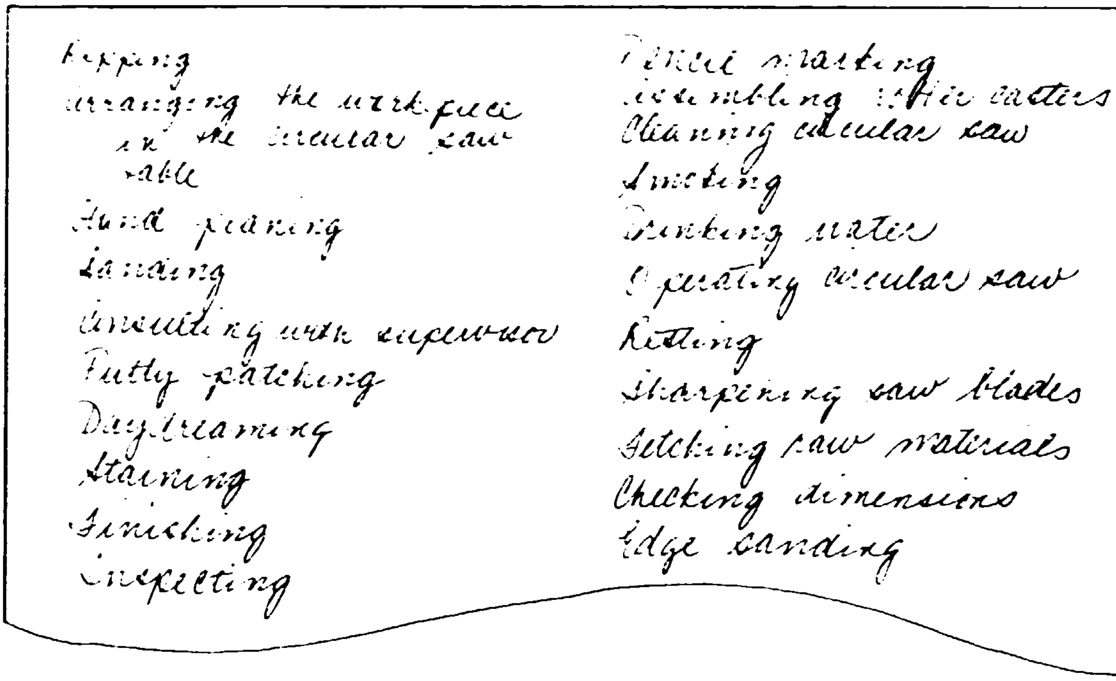
With regard to the first question, as in the case of the methods engineering processes, the assistance of the industrial extension officer can be sought. The key man in the production process should be designated the counterpart of the extension officers so that through him, in time, the process of ratio delay studies will be absorbed into the firm. Another possibility is to have the key production person attend courses on work study. There are certain other basic steps which the owner-manager should take in order to ensure the successful outcome of the ratio delay studies. These are set out below.

(a) A meeting should be called to discuss the aims and procedures of the ratio delay technique with all those people in the firm who may later be affected by the results. This step is often neglected in studies conducted in other areas of manufacturing. Taking it will not only resolve some of the doubts in the minds of the workers, but will also minimize the potential resistance to change that the results might trigger. It may also spark workers' suggestions on how the productivity of the firm can be improved - besides assuring their co-operation throughout the conduct of the study. A promise that they will not be laid-off as a consequence of the study - a promise that should be kept - is a further way of ensuring their co-operation.

(b) A firm idea should be established as to what would be the best outcome of the study. It must be borne in mind that the ratio delay study not only identifies the firm's productive and non-productive activities, but also quantifies them. At this stage, the owner-manager - on the basis of his experience in the firm - should have some idea of what the ratio of productive to non-productive activities will be. An example of this step is provided by the small-scale household furniture manufacturer who, prior to the conduct of the ratio delay study, claimed that 80 per cent of the activities performed by his workers on the shop floor were productive. The results of the study showed, in fact, that the workers were delivering only 35 per cent direct productive activities (2.8 hours per 8-hour day). Of the remaining time, 55 per cent was spent on indirect productive activities and 10 per cent on idle activities and personal comfort. Thus, the manufacturer discovered that there was much room for productivity improvement.

(c) The area selected for the investigation (group of workers, department etc.) should be subject to thorough observation and a listing made of all the activities so observed. This exercise should be conducted on "typical" working days in the firm. The listing shown in figure 30 was compiled by an extension officer.

Figure 30. Sample listing of activities performed in small-scale furniture manufacturing firms



It will be observed that the activities listed may be classified as direct productive; indirect productive; or idle, viz.:

(i) Direct productive activities. These activities add value to the raw materials being worked on. Examples are: ripping, sawing (using circular saw), hand planing, putty patching, staining, and edge sanding.

(ii) Indirect productive activities. These activities do not add value to the materials, but facilitate the performance of direct productive activities. Examples are: cleaning the circular saw, arranging the work piece on the circular saw table, fetching materials, and sharpening saw blades.

(iii) Idle activities. Examples are: resting, smoking, being absent, day-dreaming, and drinking water.

(d) The classified activities should be entered in a ratio delay form, as shown in figure 31.

(e) A trial observation should be made in order to check whether all the activities performed in the department or section under review have been accounted for. If necessary, more activities should be added to the original listing.

Figure 31. A simple ratio delay form[a]

Date: ______________ Department observed: Wood burning

Number of workers: 3 Number of machines: 3

Number of observations: 42 Type of ratio delay:

Observer: ______________ ___ Man ___ Machine ___ Man and machine

Classification	Worker No. 1	Worker No. 2	Worker No. 3	Total	Percentage of total
Direct productive activities	卌-|||	卌-|||	卌-卌	26.0	61.9
Indirect productive activities	|||	卌	|||	11.0	26.2
Idle activities	|||	|	|	5.0	11.9
			Totals	42.0	100.0

a/ Specific direct productive activities, indirect productive activities and idle activities may also be itemized and their individual percentages obtained. This will provide much more insight into the activities involved in furniture manufacturing.

(f) On the basis of the number of important productive activities registered, the number of observations to be made in order to attain the required accuracy should be calculated.[12] In the absence of statistical means of determining the number of observations, a compromise "guessed" or trial number of observations, as suggested by the majority of the workers, should be used. As a practical rule, however, the minimum number of observations should be 30, spread over a period of three weeks and made at different hours of the day.

(g) Observation rounds should be made at random times. The object of these rounds is to capture what the subject is doing (direct productive, indirect productive or idle activities) at a precise moment. Recording is simply a matter of making a stroke against the appropriate activity on the ratio delay form (see again figure 31).

(h) Data collection should continue until all activities have been observed; their incidence is then calculated as a percentage.

(i) The results should be checked for accuracy; if they are unsatisfactory, additional rounds should be made.

(j) The results obtained should be compared with those initially expected (step (b) above).

The information obtained through the conduct of ratio delay studies can be used as a rough indicator of the total productivity level of the firm; to identify the reasons behind unexpectedly high percentages of indirect productive and idle activities; to measure capacity utilization; and even to provide guidance on where to direct methods engineering initiatives. Finally, the results of the ratio delay studies can be a useful indicator in selecting a subject for more detailed study.

Time studies

Time studies are used to assess the value or content of manual operations in a furniture manufacturing firm by recording the times and rates of working for the various elements of a specific job carried out under specific conditions. The results of the time studies facilitate the determination of standard times for the jobs most frequently performed. It will be recalled that in methods engineering - as to some extent in ratio delay studies - a particular activity may be evaluated and re-designed for possible improvement. This facilitates identification of the various elements or components of the activity - elements which may be "clocked" or timed after an appropriate number of observations have been made. Standard times may be obtained from the clock readings by applying a rating factor to account for varying speeds in workers' performance. Allowance is also made for unavoidable interruptions in production. The end product is a pragmatic assessment of the productive content of an activity. This, in a nutshell, is the time studies technique. A number of distinct steps are involved in conducting time studies for highly repetitive activities in furniture manufacturing, viz.:

(a) Familiarity with the operation selected for investigation is obtained through conscientious observation;

(b) The co-operation of the worker performing the operation is enlisted. A worker should never be clocked without his knowing it, as this could lead to serious non-co-operation;

(c) Before conducting the time studies, a precise description of the conditions pertaining to the operation under review should be recorded, e.g. workplace layout and location of tools for assembly work;

(d) Timing equipment should be kept handy. For the conduct of highly formalized time studies, a stop watch is required. Stop watches are calibrated in different ways. Two of the more popular watches feature, respectively: a one-minute decimal stop calibrated in hundredths of a minute, and a one-hour decimal stop showing increments of hundredths of an hour. The former may be used in cyclic-type time studies, while the latter may be more useful in non-cyclic studies;

(e) The "elements" of the operation under review should be determined. Elements are recognizable parts of an operation, chosen for convenience of observation. They should be easily identifiable, with definite starting and finishing points (also referred to as reading points). An example of the meaning of operation elements is provided by the operator of a radial-arm saw who repeatedly performs cutting operations to produce a piece. The following elements are normally involved: (a) fetching materials from the pile; (b) measuring materials and accessories against specifications; (c) positioning wood materials in the machine; (d) setting-up and clamping the machine; (e) cutting; (f) unclamping and putting-away. Examples of break-off points in an operation which may be designated as reading points in the time study of an operation are: a distinct sound, tool transfer, or movement of materials;

(f) The number of observations required to attain a certain degree of accuracy should be estimated.[13] As a general rule, there should be no less than ten observations per operation. As in the case of ratio delay studies, the observations should be randomly spread over a period of time;

(g) Random observations should be made of the operation under review. The purpose of this is to determine the elapsed time per element of the operation. There are two ways of recording this:

(i) Using the snap-back method. The sweep hand of the stop watch is put back to the zero point at the end of every element and as soon as the elapsed time has been recorded;

(ii) Using the continuous method. In this case, the element times are recorded with the stop watch running without interruption throughout the operation. To obtain the elapsed time, each reading must be subtracted from the preceding one.

Each recording method has its pros and cons. It is probably best to start with the snap-back method, switching later to the continuous one;

(h) The average cycle time that has elapsed for each element should be computed.

Figure 32 shows a completed time study form for a small-scale door manufacturing firm. The snap-back method of recording elemental times was employed in seven rounds of observation.

By this point, the reader may have concluded that time studies can only be applied in furniture manufacturing operations that are highly repetitive and cyclical. They can, however, be applied in a highly intermittent manufacturing operation using a variation of the eight steps outlined above. For non-cyclic time studies, the procedures are as follows:

(a) Note is taken of the element of work being performed by the worker;

(b) While this action is being observed, the reading point is decided upon;

(c) The time value at the reading point is recorded while the worker continues his work;

(d) The time study is continued until the job is finished;

(e) From the time studies, a survey sheet may also be compiled, unnecessary actions being expressed as percentages of the total time taken to do the work.

Establishment of time standards

After completing the observations and computing the average time for each element of the manufacturing operation being considered, the owner-manager will be in a position to analyze the results prior to establishing standard times. In making this analysis, questions such as the following should be asked: Which of the elements observed can really be termed productive? Can methods engineering help to reduce the average observed times of the most time-consuming element? The proper response and follow-up to these questions can further improve the firm's productivity level.

A look may now be taken at the task of establishing the standard time for the operation under review. Standard time is the total time that should be taken for a qualified worker to complete a job, working at a regular pace and using established methods. The components of standard time are depicted in figure 33. Before proceeding further, however, some of the terminology employed must be clarified.

Figure 32. Example of a completed time study form

Study No: 3 Sheet No. 1 of 5 Elapsed time: 20
Department: Parts preparation
Product/Part: Door stiles No. ____
Materials: ____
Operator: ____ Skill level: ____
Operation: Cutting operation
Machine: Radial-arm saw
Tools and gauges ____ Jigs and fixtures ____
Charted by: ____ Date: ____ Checked by: ____ Date: ____

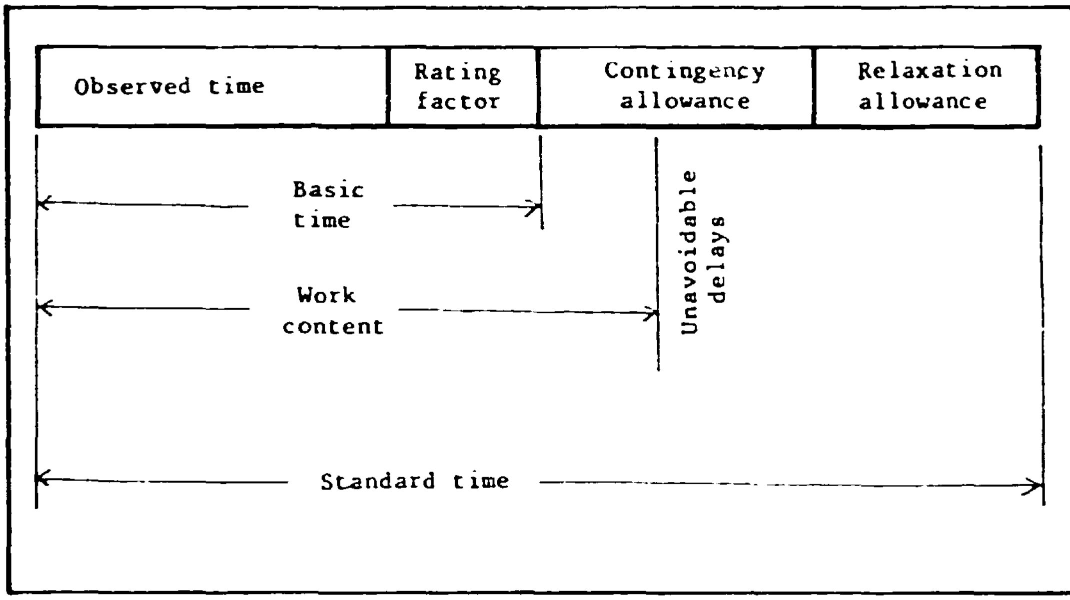
Drawing of the workplace:

Element No.	Element description	O.T.	R	O.T.	R	O.T.	R	O.T.	R	O.T.	R	O.T.	R	O.T.	R	Total observed time	Number of cycles	Average cycle time
1	Fetching materials from pile	3		2		3		31a/		3		3		2		16	6	2.7
2	Measuring materials and accessories against specifications	10		15		10		10		12		10		10		77	7	11
3	Positioning wood materials in table	5		8		6		5		5		6		5		40	7	5.7
4	Setting up and clamping machine	3		3		3		2		3		4		3		21	7	3
5	Cutting	30		32		31		30		30		31		30		214	7	30.6
6	Unclamping and putting away	10		9		10		10		8		10		10		67	7	9.6
	Totals:																	62.6

Note: O.T. = observed time R = rating factor. All time readings expressed in seconds. Snap-back recording method used.

a/ Omitted from computation of average cycle time as operator checked with supervisor (an activity foreign to this element) at about the midpoint.

Figure 33. Establishing standard time for a simple manual job



Source: International Labour Organisation, Introduction to Work Study, 3rd ed. (Geneva, 1979), p. 271.

Note: In this case, the job was performed at a pace more rapid than standard.

Observed time. This refers to the time taken for the performance of an element of the operation or of the entire operation. The time studies will yield this time. In the example given in figure 32, the overall average observed time for the door-stile cutting operation, using the radial-arm saw, is 62.6 seconds.

Rating factor. This is an increment that is added to the average observed time. It is the result of a subjective comparison between (a) the pace at which the observed worker performs the operation and (b) the observer's preconceived idea of a standard level of performance.[14/] In practice, making such comparisons tends to be complex, since there are few, if any, solid grounds upon which to base the concept of a standard level of performance. Although rating scales are obtainable, management and workers in developing countries are still at the stage of informal debate regarding the suitability of such scales in their own specific situations. If the owner-manager has had solid previous experience supervising a furniture manufacturing firm, or has been running his own firm for some time, he may be in a position to rate the pace at which a worker can perform an operation. An example of a rating scale that lends itself easily to adaptation is one that rates a worker at 0 if no activity is performed; at 50 if he performs slowly; at 75 if he does the work unhurriedly, but at a steady pace; at 100, the standard rating, if he does the work in a professional, business-like manner with an eye to quality and accuracy; at 125 if he is very fast; and at 150 if he is exceptionally fast. Combining the average observed time with the rating factor gives the basic time for the job. In the door-stile cutting example, the basic time is estimated as follows:

$$\text{Basic time} = \frac{\text{Average observed time x Rating factor}}{\text{Standard rating}} = \frac{62.6 \times 125}{100} = 78.2 \text{ s}$$

This basic time is the time it would take to cut the door stiles, using a subjective rating of 125, if the worker were performing at a standard pace rather than at the faster one shown here. The basic time for all the elements of the operation can be estimated in a similar fashion, and this will be needed if the elements throughout the entire operation are performed at varying speeds.[15]

Once the basic time has been estimated, the work content of the operation under review can be estimated. This, in simple terms, is the basic time plus the time allowances permitted by the firm. Two of the more common allowances are a relaxation allowance and a contingency allowance.[16]

The relaxation allowance is intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions, and to allow time for attention to personal needs. The amount of time allowed will depend on the nature of the job.

The contingency allowance is a small time allowance which may be included in a standard time to compensate for legitimate and expected delays, the precise measurement of which would be uneconomical because of their infrequent or irregular occurrence.

After providing for these and other permissible allowances that may be made in extraordinary circumstances, the standard time is estimated, due consideration being given to other "unavoidable" delays which may be inherent in the operation under review. In the example of the small-scale door manufacturer, the observer made the following relaxation allowances for the door-stile-cutting operation (expressed as percentages of the basic time): basic fatigue allowance, 4; standing allowance, 2; working conditions (including fumes and dust) allowance, 6; noise allowance, 5; monotony allowance, 1; and tediousness allowance, 2. A 5 per cent contingency allowance was also provided. The standard time was then established as follows:

(a) Average observed time: 62.6 seconds;

(b) Basic time: 78.25 seconds;

(c) Total relaxation allowance: 20 per cent of the basic time = 15.65 seconds;

(d) Contingency allowance: 5 per cent of the basic time = 3.9 seconds;

(e) Special allowances: nil;

(f)

Standard time	=	Basic time	+	Relaxation allowance	+	Contingency allowance	+	Special allowance		Total
	=	78.25	+	15.65	+	3.9	+	0	=	91.8 s (1.53 min)

The standard times for some of the highly repetitive steps in the manufacturing operation can then be used in estimates of direct labour costs and in the preparation of incentive schemes. (Note: plotting the standard times prior to full implementation is recommended.)

Standard times; costing and incentive schemes

The standard times resulting from the time studies will be useful in product costing activities, especially in estimating direct labour costs. To take again the example of the small-scale door manufacturer: assuming he is working on a combined job-order and rigid-type mass production operation, and that door-stile cutting using a radial-arm saw is relatively repetitive, then he can use the standard time to estimate, in a more confident manner, the labour costs of all job orders involving door-stile cutting. This is accomplished simply by converting the time unit values of standard times to their monetary equivalent, on the basis of the wages of the worker doing the job.

Let it be assumed that in the case of the door-stile-cutting operation, the standard time of 1.53 minutes is equivalent to IC 1.00. Thus, if a job order came in and door-stile cutting was part of the manufacturing process, the owner-manager could charge IC 1.00 every time the operation was performed. Let it be further assumed that after the job order has been completed it is found that this relatively fast worker (who was rated 125 in the standard time derivation exercise) spent an average of only 62 seconds performing each door-stile-cutting operation, then it may be said that the firm saved in terms of direct labour costs. These savings can then be used as a basis for providing incentives for the fast worker. Wage incentive schemes are designed to provide workers with the opportunity to earn proportionately higher incomes through greater efforts on the shop floor. Among the various schemes that are popular with small-scale furniture manufacturing firms in developing countries are: piece-rate; piece-rate with minimum base; and profit-sharing.

Piece-rate scheme

This type of wage incentive scheme pays workers a predetermined and constant amount (rate) per unit (piece) of output. This rate may be estimated using either the hourly workers' rates (here, the use of standard times is inevitable) or the appropriate amount per piece completed. The latter tends to be favoured by small firms, while the former is sometimes used for selected operations in mediumto large-scale firms. Generally, however, the practice in small firms of hiring a group of "contract workers" (workers possessing special skills and headed by an informal leader) to complement the existing work force during peak production seasons, and the simplicity of applying piece rates, have made this the most popular wage incentive scheme. Owner-managers using it should review the rates periodically. If they are high enough to assure the workers a fair return for their output, this will motivate them to increase their efforts and productivity. Conversely, low rates will have the opposite effect - if workers feel that they can never attain a wage level compatible with their needs.

Piece-rate with minimum base

An improvement on piece-rates, this scheme guarantees a minimum income for the workers if certain conditions (i.e. the production quota) are met, and additional pay if they are surpassed. Owner-managers using this scheme should establish a wage level on the basis of the production output which, it is estimated, can be attained by average-tempo workers applying the production standards resulting from the work measurement exercises. For productive work performed in excess of this estimated output, the worker will be given additional compensation. An example of the application of this scheme is provided by the finishing department of a folding-chair manufacturer catering to the domestic market. The estimated hourly output per finisher is 15 pieces. One finisher claimed that he completed 150 pieces in an 8-hour day. His base pay for that day will have to be increased by a fraction, computed as follows:

$$\frac{\text{Actual production}}{\text{Estimated production}} = \frac{\text{150 pieces}}{\text{8 hours x 15 pieces/h}} = \frac{150}{120} = 125$$

Thus, if he is paid a flat piece-rate wage of IC 1.50 per hour, increasing the estimated output by 25 per cent would allow him to [illegible] 1.25 x 1.50 = IC 1.88 per hour. If on the next day, however, he finishes only 100 pieces during the eight hours, his hourly rate for that day will still be IC 1.50, because of the guaranteed minimum base.

Profit-sharing scheme

This wage incentive scheme is popular with small-scale furniture manufacturing firms that are managed as industrial co-operatives. Here, an estimated production output is set, and if the worker or group of workers attains a much higher output, the rewards are shared by workers and employer.

Other incentive schemes can be devised for situations where individual output (the basis of most popular schemes) cannot be measured. Such schemes may include the payment of a percentage of: savings on rejects; savings resulting from a cost-reduction idea put forward by the worker; or savings resulting from energy conservation activities.

In selecting the appropriate incentive scheme, the cost-minded manufacturer should bear in mind certain factors, among them the following:

(a) The scheme should be implemented without sacrificing quality, reliability or safety;

(b) The related clerical work should be kept to the minimum;

(c) The functioning of the scheme must be understood by all the workers.

VII. COST ACCOUNTING AND VALUE ANALYSIS

Cost accounting and value analysis have always constituted weak spots in the management of small-scale furniture manufacturing firms in developing countries. The owner of one of these firms was once heard to say: "Of course we realize the importance of applying value analysis so as to reduce the unit costs of our products. But our cost system is so topsy-turvy that we cannot properly determine the cost items for all of the functions involved in the manufacture of our products." This is a typical case.

Some owner-managers are aware of the importance and usefulness of value analysis in improving their product designs, and to some extent their processes. Owing to poor cost accounting practices, however, the benefits of value analysis have never been fully realized by them.

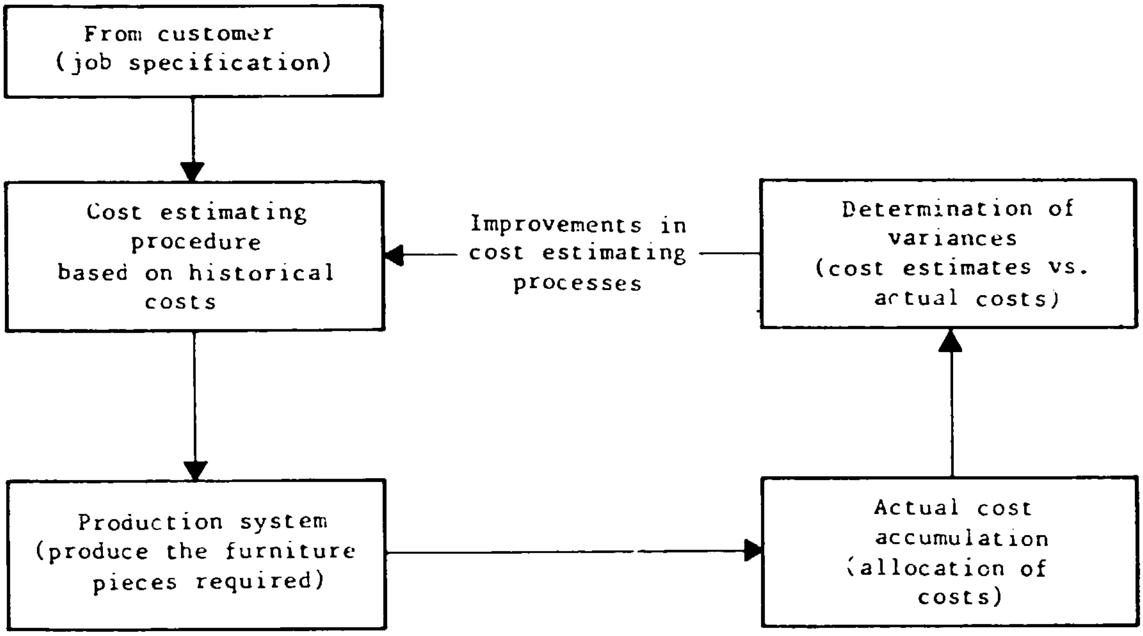
Cost accounting, for the purposes of this manual, means the compilation and study of all estimated and actual costs chargeable to a specific business transaction, for the purpose of measuring, controlling and planning management activities. (By estimated costs is meant those costs assumed prior to consummation of the transaction; by actual costs is meant the costs as they are seen following consummation of the transaction.)

Value analysis, on the other hand, is a natural outcome of an effective cost accounting system. It involves a continuing process of equating costs with functions of products, with a view to simplifying the product and improving the profit without unduly sacrificing quality or reliability. Cost accounting, therefore, is concerned with the question "How have we done in this business transaction?", while value analysis is concerned with "How should we do it next time?". It may be argued that cost accounting should be enough to deal with both issues. This is definitely not the case, however. Cost accounting essentially captures the variances between the initial cost estimates and the actual costs and should improve the firm's ability to cost-estimate subsequent business transactions. Value analysis generates alternative ways of approaching a business transaction, by determining the possibility of dropping a cost item related to a particular function of the product in order to enhance the profit posture of the succeeding business transaction - without, however, sacrificing quality and reliability. In the firm, cost accounting is in the area of budget and finance, while value analysis is in the area of production management.

Costing in small-furniture manufacturing firms: misapplications

Costing a given job or business transaction in a small firm in a developing country should be a closed-loop process, as depicted in figure 34. In theory, it starts after the customer has specified the products he requires. The firm's cost estimator - in most cases, the owner-manager himself - estimates the required production inputs - raw materials, labour, overheads etc. - and, on the basis of historical trends, estimates the costs that will be incurred. After these inputs have been acquired, manufacture of the furniture products is set in motion. From the time the production system is loaded with this job, until its completion, various costs will be continually accumulated. These represent the actual costs involved in the transaction. The variances which can be derived by comparing the original cost estimates with the actual costs should be used to increase the precision of future cost estimates, orders and contracts.

Figure 34. Costing as a closed-loop process



Note: The arrow denotes the sequence. Feedback has been omitted for the sake of simplicity.

In practice, however, costing is rarely a smooth process, as will be seen from the following two real-life cases.

The owner-manager was the primary cost estimator of Company A, a firm producing teakwood furniture products in a developing country. His brother acted as the informal purchasing and materials manager. In costing the products, the owner-manager sometimes had to rely on his intuition regarding the price of certain raw materials. One day a customer demanded a product quotation. The purchasing and materials manager was away at the time, but the owner-manager felt that as he was senior to his brother in the firm, by two years, he could estimate the price of the products required, on the basis of his own experience. Three months after the transaction had been completed, the firm's bookkeeper reported that a gross under-estimation of the material costs had resulted in the loss of more than IC 10,000 for that transaction alone.

Company B specialized in making office furniture. After completing a contract, the owner-manager was interested in finding out how much money he had made on the transaction. The part-time bookkeeper informed him, three weeks after delivery of the products, that they had made a cash profit of IC 2,000. The owner was shocked: this represented only 5 per cent of the total contract amount, and he had been anticipating a net profit of some 10 per cent. The bookkeeper insisted, however, that the firm really had made money on the transaction, as an estimated IC 12,000 worth of raw material left-overs were still on the premises, and these could either be sold or re-used to generate additional net cash profit. "But, as I do not have a contract to use such materials, nor a ready buyer for them, what do I do with them?", asked the owner-manager. The production supervisor then pointed out that the materials were obstructing current production activities.

Basic costing; cost accounting principles and terminology

As cost accounting is a broad field, this manual must necessarily confine itself to those concepts and principles that are peculiar to small-scale furniture manufacturing. The cost of any furniture product generally covers: direct materials costs; direct labour costs; and overhead costs. Each of these in turn has two principal features: quantity and price.

Direct materials costs

These cover the cost of materials incorporated in the product, and measurable as such. Certain minor materials (e.g. glue or nails) may be counted as supplies or indirect materials because of the impracticability of identifying them with specific units of the furniture product. Moreover, the unit cost may be too insignificant to be measured as a direct materials cost - in which case it should be classified under manufacturing overheads as an indirect materials cost.

Direct labour costs

These cover the labour costs directly traceable to a specific product, e.g. the salaries of machine operators and assemblers. Labour costs that cannot be linked to specific products are included in manufacturing overheads as indirect labour. Indirect labour includes storemen, foremen, drivers, clerks, inspectors, and managers.

Overhead costs

Overheads in furniture manufacturing consist of: manufacturing overheads; administrative overheads; and selling overheads. The owner-manager should have a methodology for relating these expenses to his furniture products or job orders.

Manufacturing overheads are composed of cost elements that cannot be charged direct to the product or job order - e.g. indirect materials, indirect labour, depreciation of machines and equipment, repairs and maintenance, factory insurance, and light and power.

Administrative overheads, also called general overheads, cover executives' salaries and the costs of administrative activities, as well as retainer fees for free-lance designers and management consultants, the salaries of secretarial staff, drivers, a part-time accountant and auditor.

Selling overheads refer to expenses incurred in marketing or selling the furniture products, e.g. advertising, promotion, transportation, or the paying of commissions.

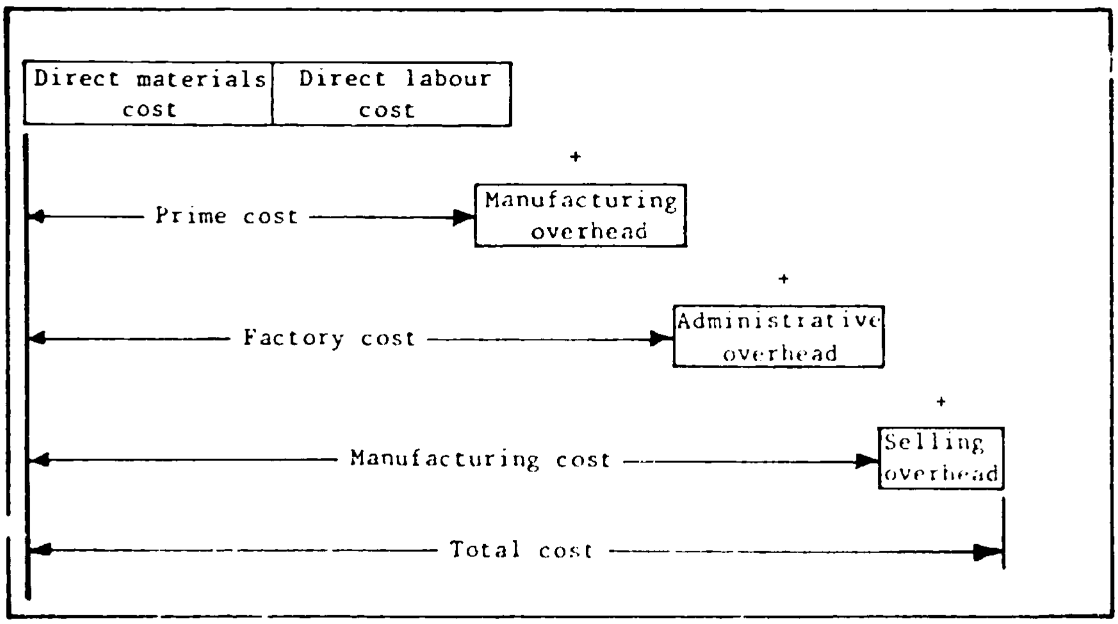
With respect to the behaviour of the various types of overhead costs, as they relate to the volume of production, the following broad classification may likewise be used:

Fixed overhead costs. These cover items such as executive salaries, depreciation, insurance, and real estate taxes. They tend to remain constant regardless of the volume of production.

Variable overhead costs. These cover supplies, power, indirect materials etc., and tend to increase as the volume of production increases.

Figure 35 shows a typical cost breakdown. The problem of allocating overhead costs is a common one to the management of most small-scale furniture manufacturing firms. Some manufacturers tend to side-slip the issue by delegating the responsibility to the company accountant, or, in the absence of the latter, by simply plucking a percentage figure "out of the air". How, then, should the overhead costs be allocated to a firm's products, or to the various job-orders processed? Generally speaking, the apportioning of overhead costs starts with the determination of a single factor which can be considered common to all the furniture products manufactured - a factor whose values will change directly with respect to the amount of overhead chargeable to the products. This factor may be, among other things, the cost of direct materials; the cost of direct labour; or the cost of machine hours. The task of allocating overhead costs tends to increase in complexity, therefore, as the variability of the furniture products increases. (This is discussed further below under "cost accounting methodologies".)

Figure 35. Cost breakdown and costing terminology



If a continuous type of production system is being used, wherein materials are the most substantial cost items and common to all products - as in the case of furniture manufacturing - the overhead rate may be based satisfactorily on the quantity of direct materials used. This is known as the direct material mode of allocating overhead expenses.

Similarly, if the products, equipment and wages are comparatively uniform, the overhead expenses can be allocated on the basis of direct labour costs. For example, if the total overhead cost is IC 50,000, and the direct labour cost comes to the same amount, then an overhead rate of IC 1.00 can be employed per IC 1.00 of direct labour costs chargeable to a product. This is aptly called the direct labour method of allocating overhead costs.

The direct labour hours method is applied when the type of work and the pay rates are sufficiently standard to permit the distribution of overheads on the basis of the total number of hours spent on the job. Thus, if on average the overhead costs IC 0.50 per man-hour, a 100 man-hour job would total IC 50 in overhead expenses. The distribution of overhead costs may not always be as simple as illustrated here, but the experience gained with each job will help in refining and improving procedures for the future.

Cost accounting methodologies

As mentioned earlier, the coverage of cost accounting in the present publication is limited to those systems commonly employed in small-scale furniture manufacturing firms, i.e. job order and contractor batch costing. Within those limits, the focus is further restricted to costing relating only to manufacturing, i.e. direct labour, direct materials and manufacturing-related overhead expenses.

Job order costing

This system of cost accounting is used when a specific job is required by a specific customer. The costs of raw materials, direct labour and factory overheads applicable to the job are compiled and divided by the number of finished units, in order to arrive at average unit costs. Job order costing is used by furniture manufacturers whose products are readily identifiable by individual unit or batch, which receive varying degrees of attention or skill. Sometimes selling and administrative overheads are charged to job costs, as a percentage of manufacturing cost, in computing the total job cost.

Where this system is concerned, the job itself is the focal point for cost identification and accumulation. Three basic types of form are used, as illustrated in figures 36-39, viz.: Job Cost Sheets (for both departmentalized and non-departmentalized firms); Materials Requisition Sheets; and Job Time Tickets.

The costs assigned to the jobs passing through the firm are initially recorded on the Job Cost Sheets. From an accounting viewpoint, these sheets represent individual pages in a subsidiary cost ledger. As a rule, each sheet is divided into sections covering materials, labour and overheads. These three elements are costed separately. The sheet also provides for recording a summary of the costs involved, as well as determination of the unit costs.

Materials requisitions provide the basis for charging direct materials to a job. In the Materials Requisition Sheet, space is provided for a description of the materials used, along with the quantities issued and the unit costs.

Job Time Tickets are used for charging direct labour cost to a job. Each worker has one time card for each job. The wage rate and the total hours put in by the worker are entered in the Job Time Card along with the corresponding costs (see again chapter VI).

In job order costing, the predetermined overhead rates obtained through forecasting or estimating are used in allocating the appropriate factory overhead rate to a job. This rate can be more precisely determined by: (a) computing total overhead costs for the job; (b) selecting a measure of activity;

Figure 36. Job cost sheet for a non-departmentalized small-scale furniture manufacturing firm

JOB COST SHEET

For: ______________ Order No. ______________

Product ______________ Quantity ______________

Date wanted ________ Date started ________ Date completed ________

Direct materials			Direct labour			Applied overhead		
Date	Requisition No.	Amount	Date	Time card No.	Amount	Basis	Wage	Amount

Summary for order No. ______

Direct materials ______

Direct labour ______

Applied overheads ______

Total factory cost ______

Factory cost per unit ______

Figure 37. Job cost sheet for a departmentalized small-scale furniture manufacturing firm

JOB COST SHEET

For ______________________ Order No. ______________________

Product ______________________ Quantity ______________________

Date wanted __________ Date started __________ Date completed __________

Direct materials

Date	Department	Requistion No.	Stores No.	Quantity	Cost per unit	Total cost

Direct labour

Date	Department	Time card number	Description	Hours or pieces	Wage	Total cost

Applied overheads

Date	Department	Basis	Wage	Total cost

Summary for order No. ______

Direct materials ______

Direct labour ______

Applied overheads ______

Total factory cost ______

Factory cost per unit ______

Figure 38. Materials requisition sheet

MATERIALS REQUISITION

Date ______________________ Requisition No. ______________________

For ______________________ Product order No. ______________________

Department

Requested by ____

____

____

Stores No.	Quantity requested	Description	Quantity issued	Unit cost	Total cost

Received by: ____________________ Date: ____________________

Figure 39. Job time card a/

JOB TIME CARD

Name ______________________ Card No. ______________________

Department ______________________ Clock No. ______________________

Date	Production order No.	Machine number	Time started	Time stopped	Total hours	Wage rate	Total cost

No. of pieces finished: ______________ Approved by: ______________________

a/ The back of this form may be used to itemize the type and number of pieces completed by the wor..er for each production order number. This is particularly appropriate for firms employing piece-rate wage incentive schemes.

and (c) dividing the overhead costs by the measure of activity to compute the overhead rate. As noted earlier, the overhead rates for various furniture manufacturing activities can be measured by using one or more of the following: direct labor costs; direct labour hours; machine hours; or prime cost.

The use of predetermined rates raises the question, however, of what to do with the difference between the overhead applied to production and the overhead costs actually incurred. If the latter is less than has been estimated, a balance of overhead will remain not charged to the job. This is known as undercharged overhead and may be carried as additional asset value in inventory, as it may tend to fluctuate from month to month. Conversely, if the actual overhead exceeds the estimated one, the result will be an overcharged overhead.

Inevitably, at the end of the year, there will remain some difference between overhead incurred and overhead applied. In reporting net income for the year, on the basis of costs actually incurred, the final net difference (either over- or under-charged) will be considered an adjustment to the cost of goods sold as reflected in the profit-and-loss statement.

Although job order costing can be a convenient and useful system to apply in even very small furniture manufacturing firms, it must be realized that its successful application entails a considerable outlay on clerical help. It is important, therefore, that job order costing be used only at the appropriate level of production and when the related expenses can be kept as low as possible.

Contract or batch costing

In contract costing, labour, materials and other costs are considered direct contract costs, overhead expenses being charged to contracts as appropriate. The actual cost of the contract may be compared with the budgeted or estimated costs as a means of checking the profitability of the job; the efficiency of the operation; or the accuracy of the estimates. As a rule, profits are ignored on contracts not yet completed. It is advisable, however, to credit part of the profit earned each year to contracts that will last for several years, in order to avoid profit fluctuation. Batch costing is also job costing for a group or batch of identical products.

The value analysis concept

Earlier in this chapter, the relationship between cost accounting and value analysis was discussed. Value analysis, moreover, was defined as a continuing process of equating costs with product function with a view to effecting product simplification and increased profit without undue sacrifice of quality or reliability. Although value analysis is not a new concept, its application in small-scale furniture manufacturing firms in developing countries has been relatively slow to find acceptance. This trend, however, may not last, because of the cost-price "squeeze" being felt in most developing countries: the market of the future will demand that quality furniture products be delivered at minimum overall cost.

At this point, the resemblance may be noted between value analysis and methods engineering or even work study process, both of which lead also to productivity or profit improvement. The basic difference between value analysis and work study lies in the fact that the focus of the former is on functions, while that of the latter is on methods. The following may be said of any value analysis initiative taken in a furniture manufacturing operation:

(a) It is a systematic and creative approach to cost reduction;

(b) It pinpoints areas where excessive and unnecessary costs are incurred;

(c) It enriches the value of the product in general as well as the value of each of the components;

(d) It will generate the same, if not better, product performance at a relatively lower cost;

(e) It does not sacrifice quality or reliability.

Value analysis methodology

In conducting a value analysis exercise in a furniture manufacturing firm, a series of five steps may be employed. This five-step process, which ought to lead to product improvement, is depicted in figure 40.

The basis of value analysis is that well-known technique called "brain-storming". This features group participation in the speedy generation of a spectrum of ideas for tackling a specific problem. (Here, again, is the opportunity to seek the co-operation of the work-force.) For maximum results, the following sequence should be adopted:

(a) The problem statement is formulated;

(b) The members of the brain-storming panel are carefully selected. (It should never be assumed that membership must be restricted to the firm. Outsiders such as suppliers or government-sponsored industrial extension officers can be invited to participate.);

(c) The panel members are given 10 to 20 minutes to note down their ideas on the problem;

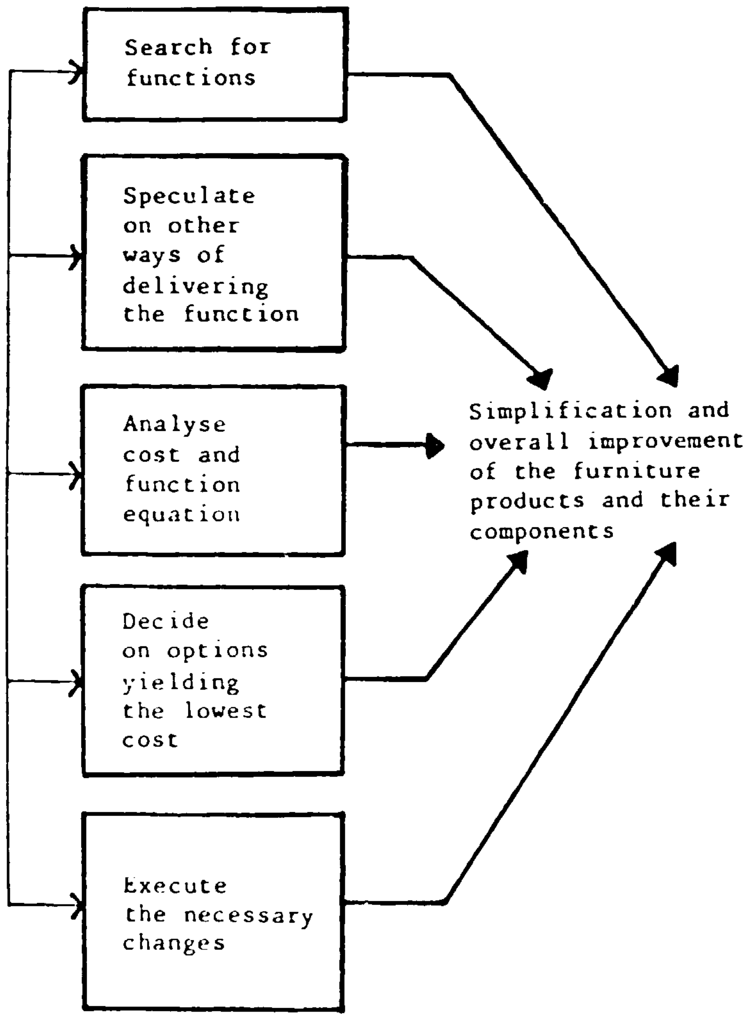
(d) The panel members are encouraged to continue generating ideas while each in turn presents his own. As the aim is to generate as many ideas as possible, even seemingly unrealistic ones should be welcome. No idea should be criticized. The combining of ideas should be encouraged;

(e) The ideas are subjected to an initial screening (only after step (d) has been completed). Should the results of the first brain-storming session be unsatisfactory, another one - this time using a more refined problem formulation - is scheduled.

Brain-storming aside, it will be recalled that systematic value analysis involves five basic steps, as depicted in figure 40: search; speculate; analyse; decide; and execute.

1. Search. The search step consists of information gathering and function defining. Assuming that a group has already been assembled to brain-storm a particular furniture product, the first stage of the search activity will be to present all the appropriate background information to the panel - information on cost manufacturing; intended use by customer; inventory levels; materials billing; flow process charts; flow charts; time studies; and the like. Upon conclusion of this, the panel prepares for the next stage: function definition. It must be borne in mind that there are four types of function: utility or use function; aesthetic or attractiveness function; possession (pride in possessing) or esteem function; and resale or trading function. Small-scale furniture manufacturers will be concerned mainly with utility and aesthetic functions.

Figure 40. Value analysis methodology (brain-storming technique)



Functions can also be categorized as primary, secondary and tertiary, however, thus giving an idea of the priority standing of each function. When defining the functions of a product or its individual components, only two words - a verb and a noun - should be employed. For example: a felt blackboard eraser, designed for the removal of chalk markings, would have the function: "erase writing". It is important that the function be defined in this manner in order to avoid, from the earliest stages, confusion regarding combinations of functions. Likewise, as a rule, the functions of a product or of its components should be precisely defined. In applying this definition of functions to furniture products, care should be taken that the various functions of the parts of the products are likewise specified and that the proper cost estimates for each component are equated with the function of the component.

Figure 41 illustrates the result of the search step in a value analysis exercise carried out on an ordinary felt blackboard eraser. It will be readily observed that the main function: "erase writing" can be delivered at an estimated cost of IC 0.30 when performed exclusively by the felt-strip component of the product. This gives ample potential for product simplification and improvement.

Figure 41. Example of search phase: value analysis of a blackboard eraser

Product: Blackboard eraser (felt)

Function: Erase writing

Parts	Functions	Estimated costs (I.C.)
Plywood	Hold felt strips	0.60
Felt	Erase writing (chalk)	0.30
Glue	Hold felt strips / Plywood	0.05
Label	Identify manufacturer	0.20
		1.15

The successful conduct of the search step is sometimes inhibited by: inadequacy of the facts gathered; basing decisions on beliefs rather than on facts; and imprecise definition of function.

2. Speculate. This step involves the systematic consideration of the various options open in delivering the function to the customer. Before the panel generates option ideas, however, through a brain-storming session, the follow-

ing questions should be answered: "Is this function necessary?", "How else - other than the way in which it is being done today - can the product deliver this function?", "Which product components do not make a significant contribution to the main or primary function?" and the like. The owner-manager, in speculating on alternative ways of delivering the intended product function, should set targets for the brain-storming panel, e.g. reduce the cost of the components by 50 per cent. This may force the panel to enter areas hitherto unexplored. It must be remembered that the aim of the speculation exercise is to find out: "What else can perform this function?".

3. Analyze. This step is concerned with the analysis and weighing of all the ideas collected at the previous step with regard to cost implications, function and feasibility. At this step (a) monetary values are assigned to the ideas and (b) the value or contribution of the ideas is questioned. At this step, the intention is not to eliminate ideas, but to analyze them with a view to determining or enhancing their feasibility and workability. Should the brain-storming sessions have led only to the generation of "conceptual" ideas, the details of these ideas should still be worked out prior to taking the next step.

4. Decide. This step contains two sub-steps: additional information; and decision/promotion. As mentioned in the discussion of the "Analyze" step, the workability of an idea needs to be assured. At the first sub-step, specialized advice should be sought on those issues which need clarification prior to deciding to implement an idea. The decision/promotion activity implies exercising judgement in choosing an idea and planning a campaign to enlist the support of those workers who may be affected, directly or indirectly, by the final decision.

5. Execute. At this step, each promising idea is appraised and evaluated. During the evaluation, additional information may be generated and used to improve on the original idea. The panel can then decide on the appropriate action to be taken for each idea so evaluated. Recommendations for action can include: dropping the idea; shelving it for a number of years; implementing it in the next batch; or implementing it immediately. The execution step ends when the likely outcome of an idea - better product design, cost reduction, improvement in current practices and methods etc. - has been determined.

Applying value analysis

From the preceding discussion, it will be clear that the application of value analysis in a furniture manufacturing operation calls for:

(a) The setting up of a panel with its own rules of procedure and terms of tenure, which will be principally responsible for the value analysis exercise. Membership may include the staff of the firm and others in a position to contribute to the improvement of the firm's products, practices and methods. As a rule, those selected for the panel should have a questioning attitude and be persistent, imaginative and tenacious in their work;

(b) The establishment of a procedure for the systematic pinpointing and review of high-cost items in the firm. Already existing cost-reduction programmes, suggestion-gathering arrangements and the like can be tied-in with the value analysis effort;

(c) The holding of regular panel meetings to evaluate the results of past initiatives; discuss current projects; brain-storm on new products or ideas presented; and establish pertinent courses of action;

(d) The conduct of value and function tests on the product and its components to determine: (i) if their cost is proportionate to their value or usefulness; (ii) if there is anything better available that can be used for the same purposes; (iii) if they can be produced at a lower cost by using improved methods; (iv) if any other firm is producing the same product or component for less; or (v) if standardized, marketable products can be produced;

(e) The keeping of thorough and accurate records covering all the ideas put forward, the deliberations on them, suggestions for their improvement etc. Reports on all projects - whether they have succeeded or failed - should be filed. The record of a project that has failed to generate usable results can be kept to forestall future similar ventures or to start a new project at the point where the previous attempt began to fail.

Value analysis and cost reduction

When value analysis is first introduced, the panel members may suggest that the exercise has been carried out before, but under the heading of "cost reduction". And, indeed, there would appear to be no significant difference between the two. Yet a difference does exist: it lies in the fact that value analysis means sustained, planned change while cost reduction means intermittent, partially sustainable change. Value analysis can also lead to benefits other than cost reduction. The most important of these is product standardization and simplification.[17/]

VIII. PRODUCTION PLANNING AND CONTROL

Scope of production planning and control

Production planning and control is the most important production management function in any small-scale furniture manufacturing firm.

Essentially, it means the co-ordination, supervision and regulation of the rate at which the various production inputs - materials, manpower, machine-time etc. - are provided to the production system in order to meet delivery schedules at minimum cost. In a small firm, it encompasses the following tasks:

(a) Planning - forecasting sales, determining which products to produce, the amount of materials required, the processes to be performed etc.

(b) Routing - selecting the path through the manufacturing system which the product (or job-order) must follow in order to achieve scheduled deliveries at minimum cost. Here, it must be decided which machine to use and who will use it.

(c) Scheduling - preparing and monitoring production timetables and, in cases of job-order production, scheduling the incoming job orders bearing in mind the delivery requirements of other job orders on hand.

(d) Dispatching - authorizing the loading of a job order and sending it to manufacturing. This simultaneously releases the raw materials, tools, jigs, fixtures etc. required for the manufacturing operation.

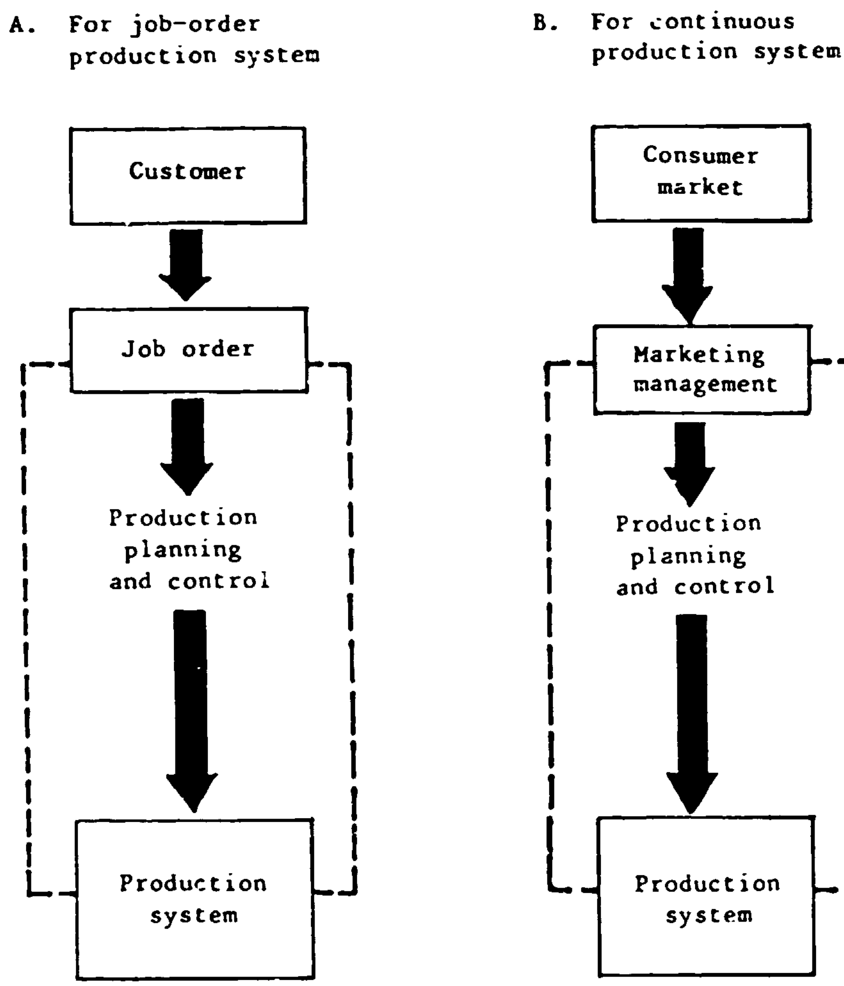
(e) Expediting - assisting or fostering the performance of the various manufacturing operations, minimizing or eliminating "surprises" that may develop along the way.

Production planning and control, therefore, acts as an interphase between the market and the firm's production system, as depicted in figure 42. In developing countries, the typical owner-manager of a small-scale furniture manufacturing firm tends to perform all the production planning and control tasks besides the more functional ones involved in day-to-day management of the firm. In performing these tasks, however, he is seldom in possession of all the information necessary to make correct decisions. The result is that the goodwill of the firm suffers, as failing to live up to delivery commitments is a sure way to lose customers.

A corollary to this unhappy practice is the persistent reluctance of some owner-managers to inform plant supervisors and workers of the production schedule (which is stored in his head). This situation can bring a firm's production activity to a halt as the workers await instructions on what to load next. This problem, which can severely drain productivity and resources, can be rectified simply by setting up a production schedule.

In order to simplify the explanation of what constitutes production planning and control in furniture manufacturing, the two functions are treated separately below. In practice, however, they go hand in hand. Generally speaking, production planning consists of: co-ordinating the production function with other areas of the business; determining what products to produce, based on market study; calculating the quantities involved, based on sales forecasts; scheduling delivery; programming requirements of materials, parts, labour and facilities; and synchronizing the contributions of the finance, personnel, purchasing, marketing and administrative sections to the

Figure 42. Production planning and control as an interphase between market and production system



overall production activity. Production control, on the other hand, involves: monitoring all activities within the production department, thereby promoting effective shop operation; co-ordinating manufacturing activities in line with production plans; routing, loading, scheduling, expediting and following-up; identifying deviations from the production plan during the manufacturing processes; finding the causes of such deviations and suggesting ways of eliminating them.

Production planning

Figure 43 shows a simplified production planning scheme for a small-scale furniture manufacturing firm. Even simplified, the task of production planning involves a number of steps and requires inputs of various types of information. The process is seldom as systematic-looking as the one depicted, as in most cases planning activities are performed and stored in the head of the manufacturer. One consequence of this is that the manufacturer may give in to changes of mind, with resulting confusion and frequent changeovers in production loads. Moreover, a manufacturer with a lot on his mind is liable to forget plans that he has only mentally recorded.

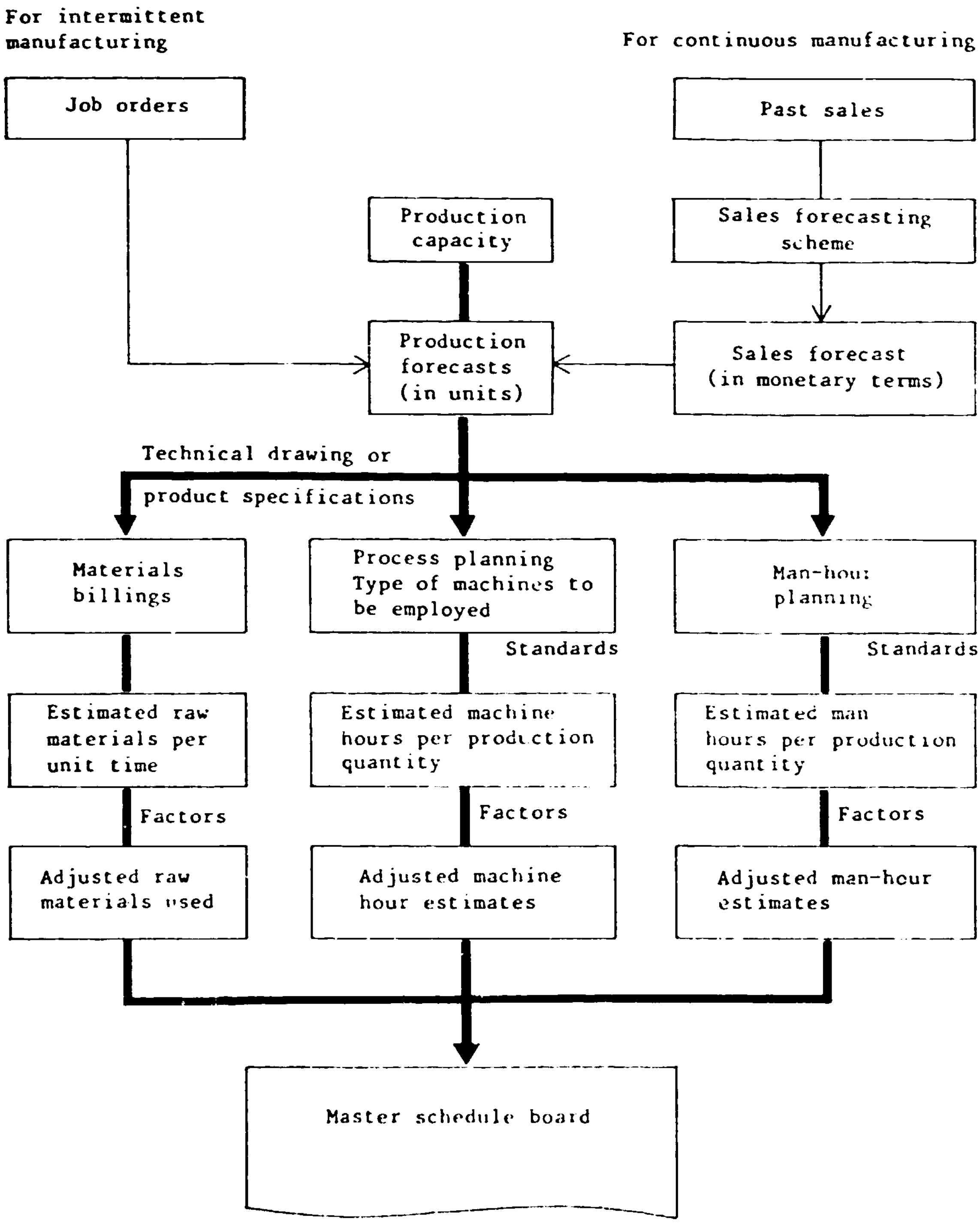
Production planning commences with awareness of the production capacity of the firm. Production capacity, in theory, is the maximum output that could be produced if there were no such thing as internal and external constraints. In reality, however, machinery, equipment and staff seldom operate without such influence: hence the term "effective capacity". This is always less than production capacity, because of the physical, product, process and human constraints that hamper the production of furniture products. Physical constraints may be the consequence of faulty plant location, layout, or materials handling procedures, among other things. Product constraints may have their roots in, for example, standardization and simplification efforts; the number of product lines or designs carried; or the quality and material requirements attaching to the products. Human constraints may be related to work methods; labour intensity; morale; working conditions; compensation and remuneration patterns; and the level of experience of the workers.

The effective production capacity of the firm acts as a "filter", separating jobs that can be accommodated on a one- or multiple-shift basis from those that might be sub-contracted to other firms. In intermittent furniture manufacturing operations, effective production capacity is generally expressed in terms of production hours. In continuous operations, it is expressed in terms of quantities per unit of time, e.g. 300 school desks per month. Thus, effective production capacity should be generally in accordance with production forecasts. The primary source of information for intermittent operations is the job-order, while that for continuous operations is the sales forecast.

Preparing production plans

On the basis of technical drawings, product specifications and/or a sample product, the total materials requirements are estimated. Initial estimates of raw materials (direct and indirect) should allow for spoilage, wastage, economic quantity ordering, re-order points, offcuts, existing inventory, and the like. At the process planning stage, the types of machinery needed to manufacture the product, as well as the estimated machine-hours required per process, are listed. Similar jobs carried out in the past will serve as a basis for the initial estimate of total machine-hour requirements. This estimate may be adjusted later to compensate for such factors as potential machine breakdown, repairs, power supply irregularities, and availability of operators.

Figure 43. A simplified production planning scheme for a small furniture manufacturing firm



Process planning is followed by man-hour planning. This process begins with the identification of all the areas of production where manpower inputs will be required. Man-hour estimates may be made using rough standards based on workers' experience levels and records of absenteeism, moodiness, tardiness etc. In some cases, man-hour planning is much simpler than process planning, because more than one worker may be assigned to a machine. The data provided by the materials billing, process planning and man-hour planning procedures will serve as inputs to the preparation of a "master schedule board" which should contain all the relevant information that is available regarding job orders on hand or in process, jobs to be completed, and so on.

From sales forecasts to production plans

In continuous manufacturing operations, the sales forecast is the basic information input to the formulation of a production plan. Sales forecasting refers to the ability of the owner-manager to plan in advance - by estimation and calculation - the future sales volume of the firm and the resources and activities needed to attain it. The increasingly scientific methods of estimating future sales have provided small-scale furniture manufacturers with a more sure approach to setting sales goals. Although the results of these initiatives may still, in many cases, be mere "guesstimates", such forecasting is vital to the preparation of the firm's budget and production plans. But how does one prepare a sales forecast?

A variety of techniques are available, ranging from the highly intuitive to the highly scientific. Simple approaches consider only a firm's production in relation to its share of the market, while more detailed approaches would take into account the state of the economy and possible substitution by or of the product manufactured. In the present publication, an attempt will be made to introduce scientific, but simplified, forecasting procedures. No matter which procedure is ultimately chosen, however, the following should be kept in mind:

(a) Whenever possible, scientific methods should be used to process sales forecasting data. When using the scientific approach, "cause-and-effect" relationships should be searched for which would justify - or not - the results obtained;

(b) Sales forecasting techniques should be used only as tools. They are "true" only to the extent that they are based on assumptions;

(c) Sales forecasting expenses should be kept to a minimum;

(d) The technique should be thoroughly understood by the user, who should never, in any case, rely on the results of only one method;

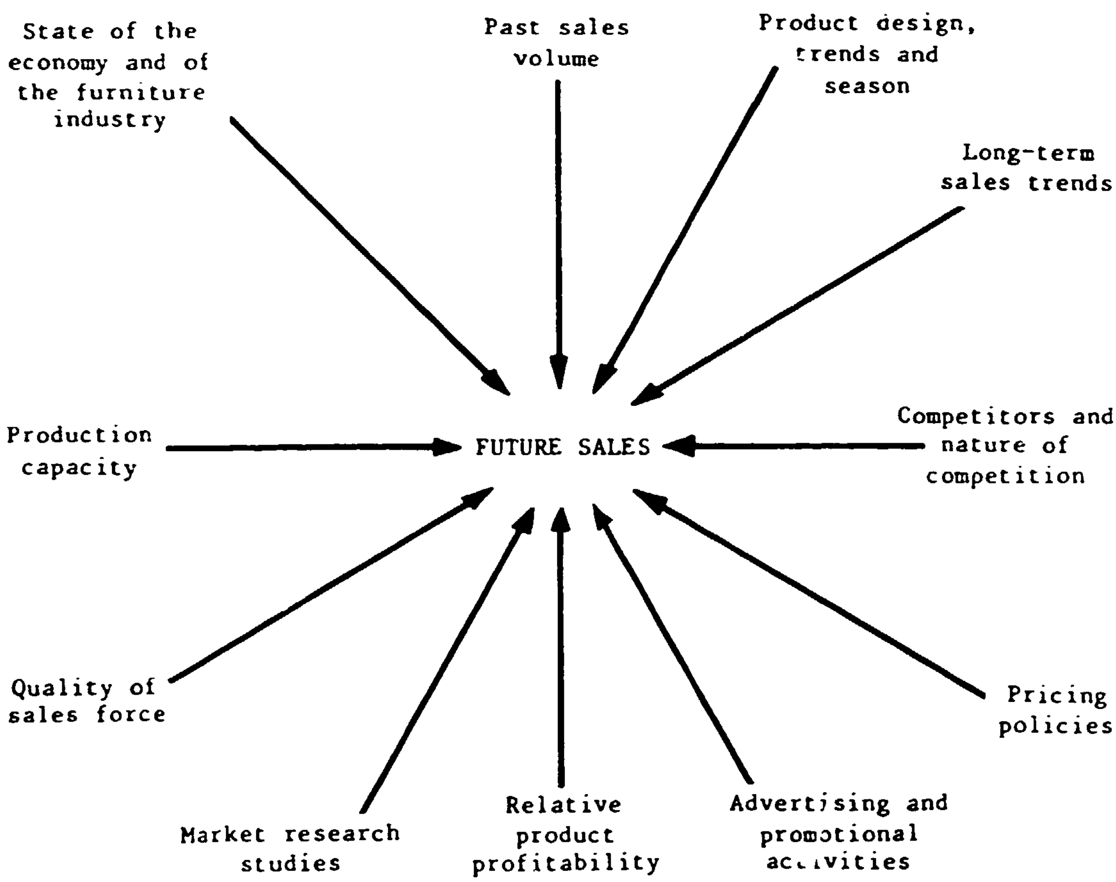
(e) Results expressed in ranges are preferable to absolute values;

(f) Attempts should be concentrated on generating accurate forecasts for the short term (some weeks or months). Long-term projections (e.g. 3 years or more) should at best be considered mere prospects;

(g) The procedure should be subject to continuous revision and updating.

Figure 44 shows the various factors that can have a positive or negative effect on future sales volumes.

Figure 44. Factors affecting future sales in small-scale furniture manufacturing firms



Sales forecasting techniques

The following forecasting techniques are particularly appropriate for small-scale furniture manufacturing firms.

Executive judgement method

Essentially non-mathematical, this method begins with the firm's salesmen being asked to submit their estimates of future sales. These are reviewed by the salesmen's immediate managers, who may adjust them if it is considered that the salesmen have tended to be too conservative in their estimates. The final (managers') estimates are then transmitted to a special committee charged with drafting the final forecasts. (In very small firms, this function is assumed by the owner-manager.) The committee would likely be composed of: the head of the marketing department; the head of the production department; the company treasurer; the company president; and the company secretary. The committee reviews, revises and adjusts the sales estimates in the light of other factors that the salesmen and their managers have not been in a position to consider, such as: expected changes in product design; possible increased use of advertising; probable adjustments in selling price; planned improvements in project quality; expected revision of marketing strategies; and probable economic changes as a spin-off of changes taking place on the national scene. This final revision represents the official sales forecast for a particular product.

Derived demand method

Also non-mathematical, this approach is particularly appropriate for sub-contractors who depend on orders from another company. The sub-contractor's forecast could be based totally on the sales projection figures of the other company. For example, a small firm producing wooden cases for a bottling company can base its sales forecasts on the sales projections of the bottling company.

Market indicators method

Market indicators are economic factors that influence the demand for a product. In using these for forecasting purposes, the main idea is to obtain the increase/decrease rate of sales volume. This is especially applicable to products that behave according to a specific market indicator. A difficulty in applying the method, however, lies in the fact that some products are directly affected by a number of market indicators. Among the more common market indicators are: (a) population trends (population magnitude; birth rates; death rates; marital trends; migration; age patterns); (b) construction trends (private and public building); (c) foreign trade developments (import and export activities); and (d) general economic conditions (increases in gross national product, unemployment rates, inflation rates). In the case of furniture manufacturing, the volume of construction activity in an area can be an indicator. Marriage and birth rates can also be used, but these tend to be weak indicators.

Arithmetic method

If a firm has been in existence for some time, sales projections can be based on past sales data. The objective in using historical figures analysis is to compute average increases or decreases for a given forecast period, using the Simple Average Annual Increase (SAAI) system, as shown in the following example;

The annual sales record of a small-scale furniture manufacturing firm is:

Year	Sales (thousands of IC)
1	45
2	52
3	39
4	42
5	65

Using the arithmetic method, the following computations are obtained:

	(thousands of IC)
Sales in year 5 =	65
Sales in year 1 =	45
Increase in 4 years' operation =	20

Thus, SAII = 0.5 (obtained by dividing the increase by the years of operation).

Sales projections

Year	Sales (thousands of IC)
6	70
7	75
8	80

Year-to-year change method

It will be observed that using the arithmetic method only the last year (5) and the first year (1) were used in projecting the sales volume. The years in-between were virtually disregarded. In the year-to-year change method, however, the changes (positive or negative) are considered for each period, as shown in the following example:

Year	Sales volume (thousands of IC)	Year-to-year change (thousands of IC)	Percentage change
1	45	(base year)	
2	52	+7	+15.6
3	39	-6	-13.3
4	42	-3	-6.7
5	65	+20	+44.4
Algebraic sum		+18	+40.0

Thus, the year-to-year change of + IC 18,000 for a period of 5 years - or IC 3,600 per annum - can be used in projecting the sales volume. The average annual growth at 8 per cent (40.0 - 5) can likewise be used in forecasting sales.

The above are examples of possible techniques for sales forecasting. As soon as the forecasts are finalized, the production plan can be prepared. At this stage, instead of monetary units, the sales forecasts will have to be expressed in production volume equivalents. This is accomplished by considering the unit price of the product (for single-product firms) or the average price of the product (for multiple-product firms) together with the sales forecast results. Care should be exercised when using the average price for firms whose prices vary significantly. Still another way of converting the sales forecasts of multiple-product firms is to apply the percentage distribution of each product line to the total sales volume generated in the previous year. These percentages can be used as the basis for determining the contribution of each product line in succeeding years.

From job orders to production plans

Production planning for a continuous-type manufacturing operation is relatively simple compared with that for a job-order production system. This is primarily because planning *per se* tends to be more difficult in the latter case. The basic information for the preparation of a production plan for a job-order operation is entered in a production planning sheet, a model of which is shown in figure 45.

Figure 45. Production planning sheet for a small-scale furniture manufacturing firm

1. Job order No. ____________
2. Customer ____________
3. Address ____________
4. Contact ____________

____

5. Date received ____________
6. Volume needed ____________
7. Other information ____________

____

____

8. Product specifications

8.1 Standard product lines

Additional specifications (moisture content, finishing modification etc.)

Conditions of delivery

8.2 Made-to-order products

Product design/technical drawing

Breakdown of parts/ components and fittings

Additional specifications (type of materials, finishing etc.)

Conditions of delivery

9. Materials list	Unit	Quantity/piece	Total quantity required
1. Wood and lumber materials			
2. Upholstery materials			
3. Hardware			
4. Other			

10. Manufacturing processes for standard product lines

Manufacturing processes	Machines, jigs, fixtures to be used	Estimated machine-hours required	Estimated man-hours required	Total	
				Machine hours	Man-hours

11. For made-to-order products

Parts	Machines, jigs, fixtures to be used	Estimated machine set-up	Estimated machine hours	Estimated man-hours	Total

Note: The estimated machine set-up time includes the time needed for the trial run.

12. Adjustments estimates

Materials (allowances for non-availability, rejection rates, scraps etc.)

Machine-hours (i.e. allowances for power failure, machine breakdown etc.)

Man-hours (absenteeism, tardiness etc.)

13. Prepared by: ____________ 14. Verified by: ____________

15. Approved by: ____________

The production planning sheet inquires (item 8) whether the product needed is standard or made-to-order. If standard, then besides the materials (item 9), the manufacturing processes - including the machines and equipment needed - will have to be listed in detail. In firms using relatively sophisticated techniques, index cards may have to be consulted when filling in the manufacturing processes columns (item 10). The index cards should contain details of all standard product lines carried by the firm. For non-standard products, item 11 should be filled in. Various adjustments can later be made (if necessary) to allow for unexpected delays. Records of these adjustments will help the owner-manager in future estimating of realistic delivery dates.

Again, in the more sophisticated, medium-sized firms, a card detailing the process flow of the product is prepared. This accompanies the components throughout the factory, serving to inform workers about the next operation, how the machine is to be set up, which jigs to use etc. This card also states the exact operation to be carried out on each machine, describing the special tools or jigs that may be needed. A space is usually provided for the workers to initial when an operation has been completed, or to list the starting and finishing times of pieces machined if they are working on a piece-rate basis. As a rule, this card is encased in a plastic folder bearing a dimensioned sketch of the finished component, enabling the operator to set the machine for each operation.

After capacity, availability and other adjustment factors have been taken into account, the scheduling process may be started. The objective of scheduling in manufacturing, whatever the scale, is to prepare, allocate and make available all the physical inputs needed in the manufacture of goods or the provision of services, in order to ensure that:

(a) All job orders are executed in the shortest possible time;

(b) Estimated delivery dates are based on reliable information;

(c) A continuous supply of work flows to each process; and

(d) Plant supervision can be kept to a minimum.

Figure 46 gives an example of a general production plan for a job-order system. Such plans must not be too rigid; there should be leeway for any revisions that may have be made if:

(a) A new product (or job order) is added;

(b) Changes are called for in the design of a product (the result, for example, of rationalization, standardization or product adaptation efforts, cost effectiveness schemes or productivity studies);

(c) A need is seen to reduce production costs (through greater utilization of existing facilities) or to minimize labour or materials costs;

(d) Processes, equipment or methods become obsolete;

(e) It is decided to introduce more effective supervision and production control.

Plans may be revised through (a) periodic adjustments (in small plants that change products and accept job orders at regular intervals); (b) continuous adjustments (in small firms employing job-order systems with very short production cycles); or (c) accidental adjustments (upon discovery, in the course of production, of new or improved methods or processes).

Figure 46. Production plan for a job-order manufacturing system

Job order No.	Date received	Date of delivery	Quantity required	Materials required	Man-hours estimate	Machine-hours estimate	Volume per week	First machine loading date	Production to date

Basic production control procedures

Basically, production control means regulating, synchronizing and co-ordinating all the activities involved in manufacturing in order that delivery dates can be met, plans implemented with optimum efficiency and economy, and the right quality achieved using minimum capital investment. All furniture manufacturing companies, big and small, are beset by the following problems:

(a) How to satisfy customers' delivery and quality requirements;

(b) How to reduce production costs, thereby lowering the price of the product;

(c) How to maintain a minimum level of capital investment;

(d) How to streamline the production cycle.

These problems sometimes seem insoluble, as they appear to be inconsistent with one another. Salesmen and other marketing staff clamour for quick delivery, production personnel for more time, and financial staff for reduced capital expenditures.

The basic elements of a control system must be present in production control. Figure 47 illustrates the basic production control concept. Here, subject to control is the rate of production that will permit the realization of all delivery commitments at a relatively low cost. A daily production (or accomplishments) report should be prepared in order to keep track of the day-to-day rate of production. This report should tally with the production plan (which outlines the desired rate of production). Deviations from the production plan are recorded in a daily production variance report. Each deviation must be explained by the persons responsible, who should, besides,take the necessary corrective action. The production plan may sometimes need to be adjusted in the light of information acquired subsequent to the production planning stage. Production control is a continuous process of adjusting the actual production rate to measure up to the desired one.

Very small firms may consider that the basic production control concept is too sophisticated for their needs. In this event, a simpler approach could be employed, based on the use of a "production monitor chart", as explained later in the present chapter. In general, an efficient production control system helps to: systematize job-order scheduling; optimize the utilization of men and machines; provide better control of work methods; maximize workers' satisfaction, besides increasing their effectiveness; minimize waste; and bring to light more profitable options for manufacturing specific products.

Order and flow production control systems

There are two basic production control systems: order control and flow control. The two systems exist because there are two general types of manufacturing process: continuous and intermittent. It is difficult, however, to classify companies by type of manufacturing process, since some use both.

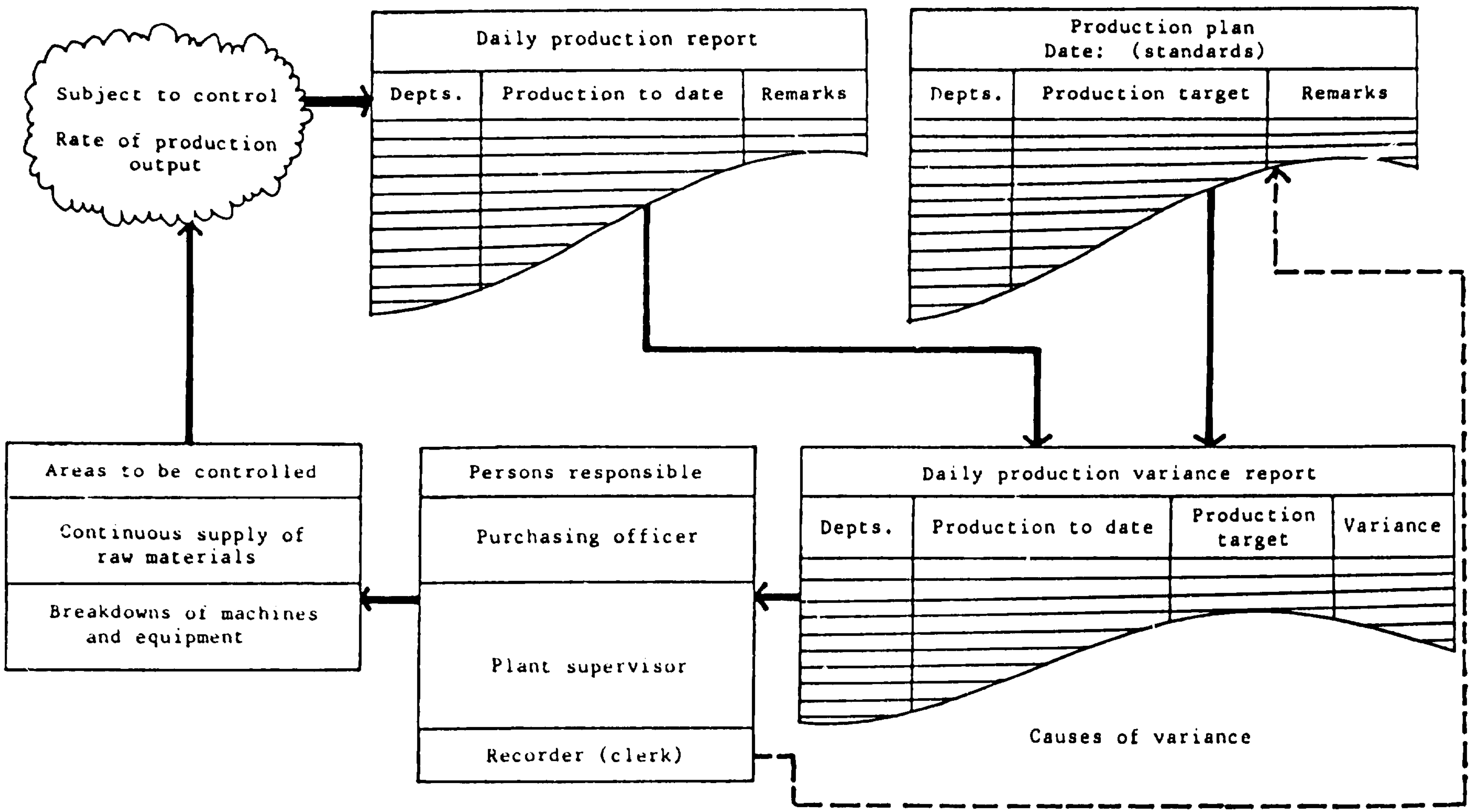
Order control system

A firm uses the intermittent process when it:

(a) Manufactures wide varieties of products per order;

(b) Manufactures small quantities of units that are seldom re-orders;

Figure 47. Basic structure of a production control system



(c) Uses multi-purpose machinery and equipment in the processing of its products;

(d) Is laid out along the lines of the production process;

(e) Bases its manufacturing activities on past sales records.

These cases call for the application of order control.

A feature of the order control system is that the process of production control actually starts with the signing of the contract or agreement between the firm and the customer, regarding the type, quantity and quality of products to be produced, and the delivery date. The elements of this agreement are embodied in the Production Planning Sheet (see again figure 45) - and sometimes in the Job Order Sheet. A routing scheme may subsequently be devised showing the most appropriate flow of materials within the plant in light of the various manufacturing processes required. The estimated time, raw materials and the machine-hour requirements for each manufacturing step involved in a specific job-order should be included in the routing scheme. This will lead to the establishment of an effective production schedule, and ensure that products will arrive at the finished goods storeroom on the date stipulated. To guarantee the success of this operation, the following steps should be taken:

(a) The product should be divided into its major and minor components and the decision made as to whether to make or buy them. This means determining in advance which parts or components it would be economical for the firm to make and which could be more economically bought outside.

(b) The owner-manager should make himself thoroughly familiar with the alternative ways of delivering the services stipulated in the job-order, in order that the most economical process will be selected prior to inserting the job-order in the production system;

(c) It should be ascertained that the various procurement lead times for the required raw materials are realistic;

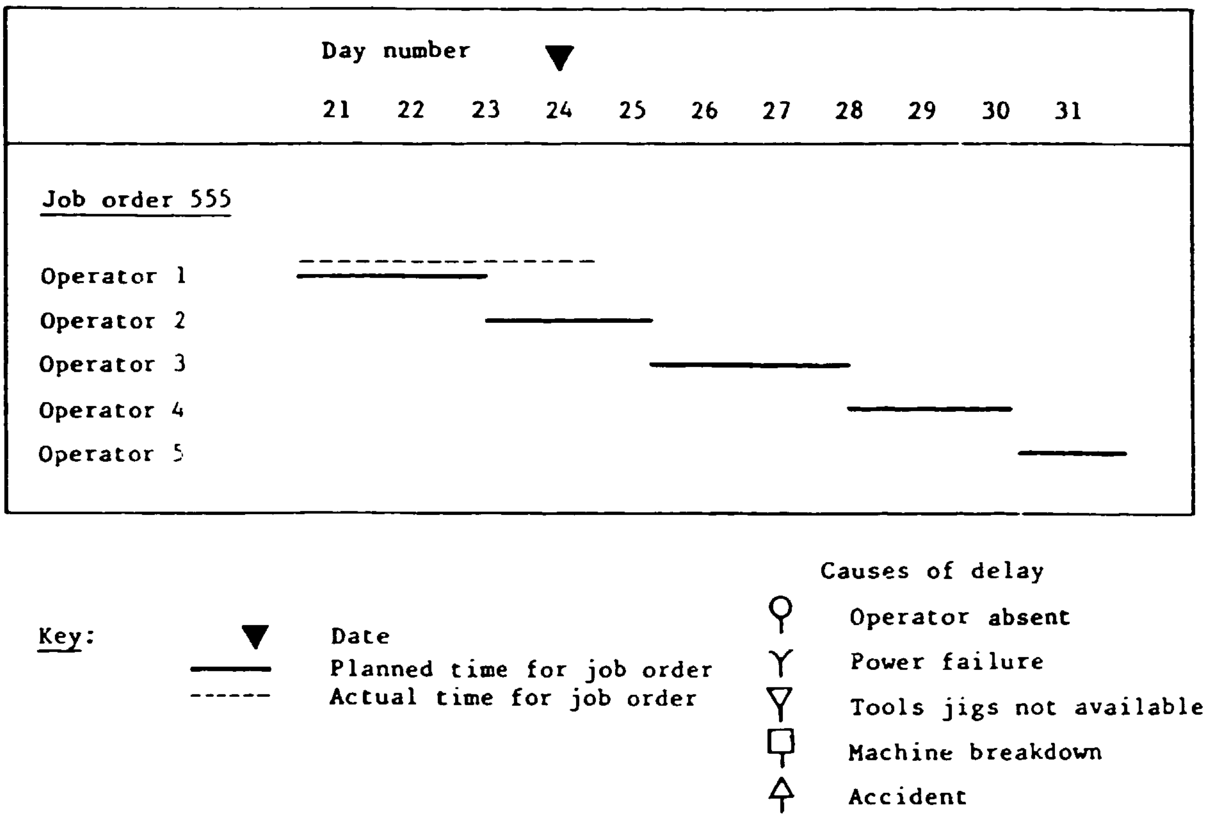
(d) The situation regarding job orders in process, as well as those scheduled to be processed, should be carefully considered before fixing a schedule for the new job order.

At this point, a formal schedule is prepared, preferably using a Gantt chart or the PERT (Programme Evaluation and Review Techniques) Network Analysis.

The Gantt chart shows, in descending steps, all the time and activities involved in a process, from the procurement of the raw materials to the completion of the product. In furniture manufacturing, two types of Gantt charts may be employed: a machine record chart and an operator record chart. Both use similar procedures and differ only in the type of "causes" of failure to meet production plans. An example of a Gantt chart for a particular job order is shown in figure 48.

The PERT Network is a logical representation of the sequences and procedures involved in all the manufacturing activities associated with a given job order, using PERT principles of programming. At the moment, the PERT Network is applied only in sophisticated medium- to large-scale furniture manufacturing plants.

Figure 48. Gantt chart (operator record type)



The scheduling process will never be completed satisfactorily unless a production monitoring chart is employed which illustrates the stage-by-stage completion of the various job orders. Figure 49 shows an example of such a chart. Out of this production schedule will evolve a summarized report on the process of every job being processed. A format of a typical such report is shown in figure 50.

In dispatching, which follows scheduling, the primary aim is to maintain lines of communication with all those concerned in the manufacturing processes to ensure that materials and products move from process to process as planned and on schedule. Dispatching involves:

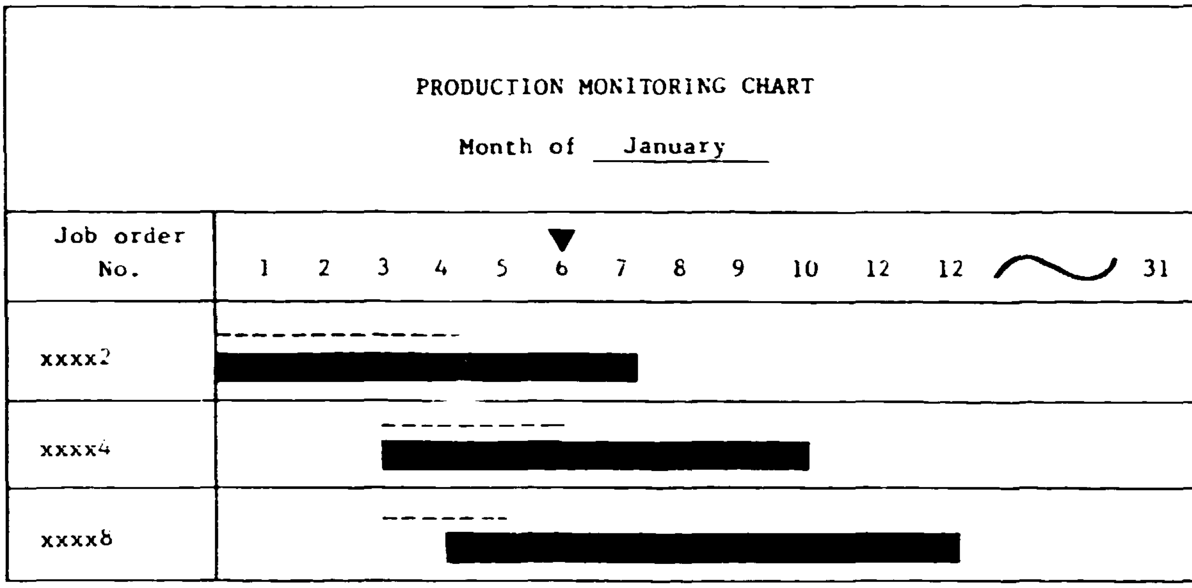
(a) Co-ordinating all production schedules prior to their release to the various departments concerned;

(b) Machine and manpower loading, which means assigning specific jobs to specific machines and workers;

(c) Reporting and arranging feedback on the status of each job order being processed in the plant;

(d) Controlling work-in-process. This task involves assuming responsibility for uncompleted work after a certain date, reporting the level of work-in-process, the amount requiring re-work and the amount of scrap materials generated.

Figure 49. Production monitoring chart



Key: ▬ Planned production (in units)

------ Actual production to date

▼ Date today

Figure 50. Format of a job-order processing report

Job-order processing report for the month of ...					
Customer	Job order No.	Past due	This week	Next week	Remarks

If the production planning and control functions of an intermittent manufacturing operation have been well laid out, "expediting" should not be necessary. This, however, is seldom the case: schedules are not adhered to, machines break down, and other production mishaps occur - hence the need for a production expediter. Production expediters have an intimate knowledge of the firm's products, processes, machines, routing schemes etc. in order to be able to predict and forestall the occurrence of production set-backs.

Flow control system

The flow control system is applicable to small firms that employ the continuous manufacturing process. Such firms are generally characterized by: the large-volume production of standardized products; the departmentalization of the plant by product; the use of special-purpose machines; the tendency towards long-term sales contracts; and production for stock.

The primary function of flow control is to provide adequate control of the rate at which a product or material "flows" through the firm. A firm employing the continuous manufacturing process can reap the economic advantages of the mass production system - i.e. speed, low inventory in process, low unit costs, simpler supervision, and simple production control methods. Even if flow control is relatively limited in application vis-à-vis order control (e.g. in intermittent manufacturing) the basic elements remain the same: routing, scheduling, dispatching and expediting.

In continuous manufacturing, the production department must be told what to produce, in what quantities and by what date. Continuously manufactured products are usually standard products, i.e. they are produced for stock and not against customers' orders. The rate of manufacturing will be based on the company's sales forecasts.

The basic elements of flow control are routing, scheduling and dispatching.

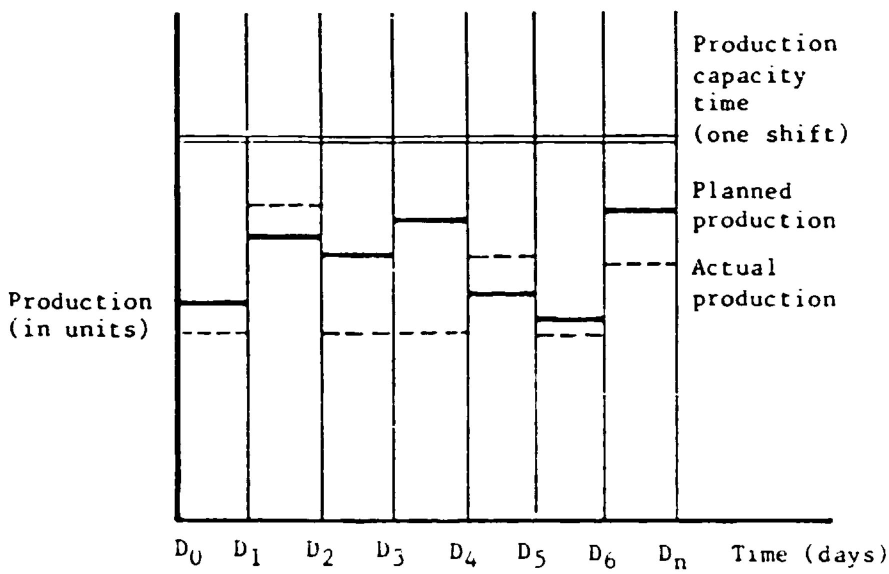
Routing. The production staff must be familiar with the different processes involved in the manufacture of the product. This is important because the processes may require special parts and tools.

Scheduling. As mentioned earlier, the scheduling of continuous manufacturing is much easier than that of intermittent manufacturing. The Gantt chart lends itself well to flow control methods. In addition, however, charts to monitor production progress should be used. Figure 51 shows two examples of production monitoring charts for continuous-type furniture manufacturing. Critical to effective scheduling is the procurement, in good time, of all the necessary materials, so that the production processes will not be hampered or delayed.

Dispatching. After the operating schedules and plans have been considered, the production control department contacts the purchasing department regarding the procurement of the raw materials. It then gives the production personnel instructions on the manufacturing processes to be employed. For continuous manufacturing, these instructions will be relatively complicated. For this reason, most small companies engaged in continuous manufacturing do not employ dispatch forms.

Figure 51. Production monitoring charts for continuous furniture manufacturing

Example A



Example B

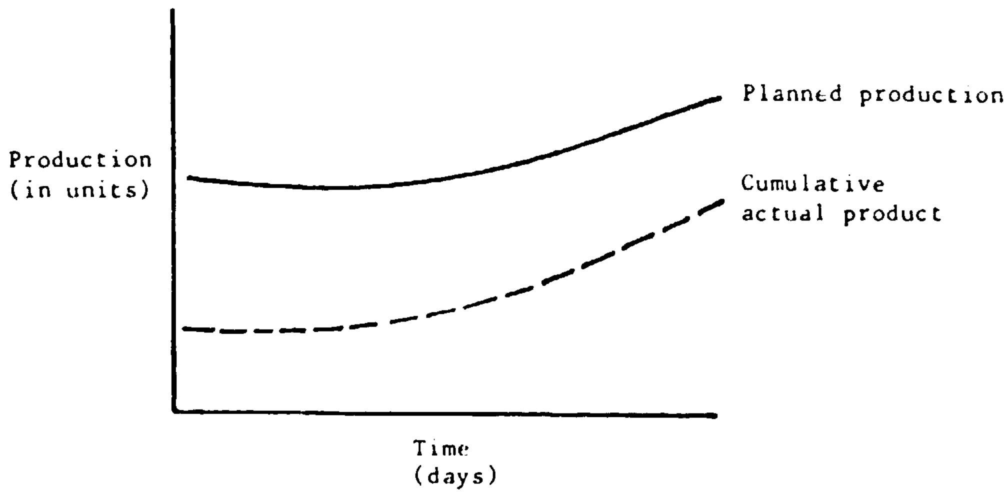
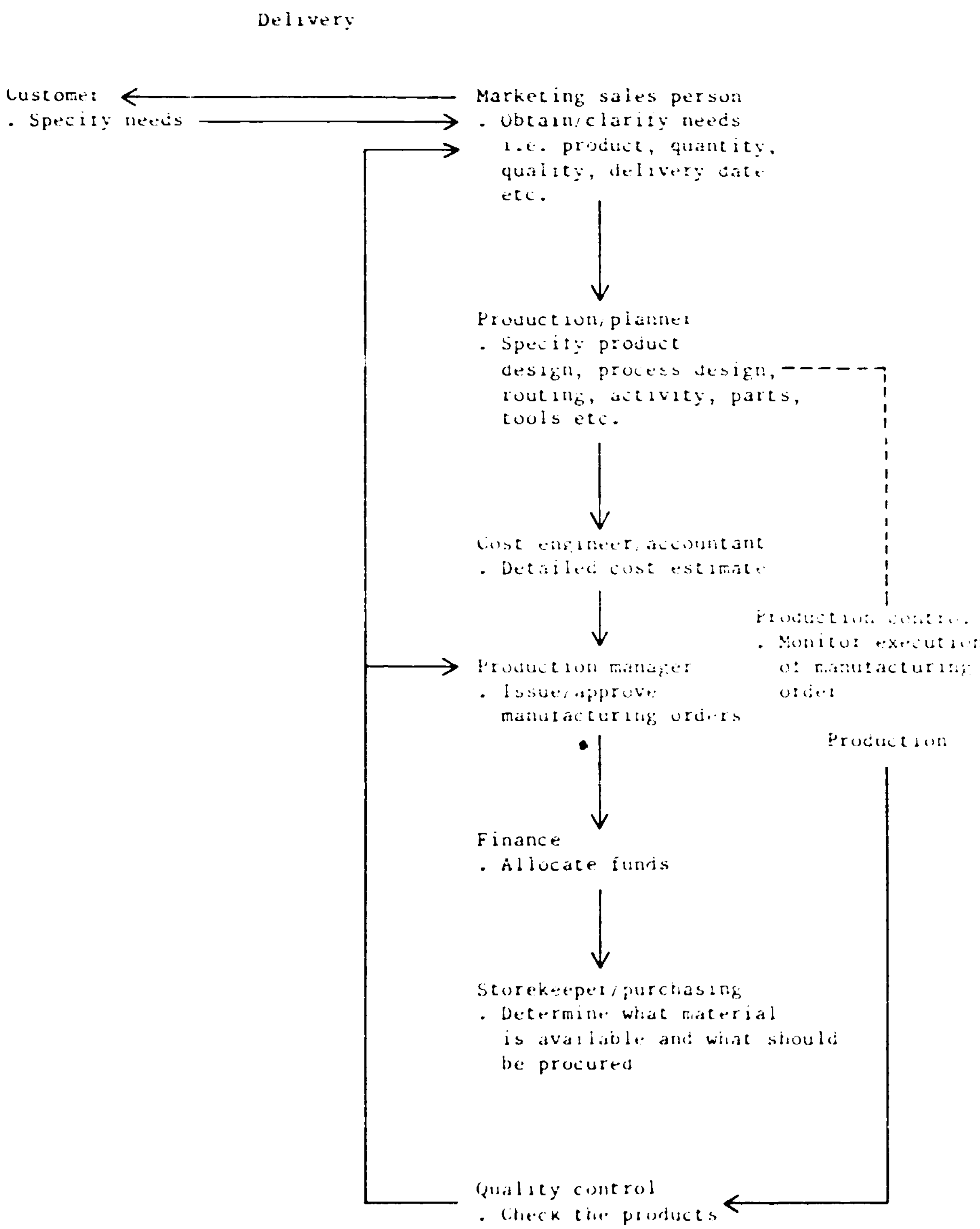


Figure 52. Relationship between production planning and control and with areas of the firm



Production planning and control and its links with other areas of the firm

Production planning and control activity is a critical element of the "creative" function of a furniture manufacturing firm (figure 52). It is the connecting link between the marketing and the production phases - a link that starts with the marketing department's job of determining the quantity, initial specifications, and delivery time of the product. This information is forwarded to the production planner who is responsible for, or who co-ordinates, the product and process designs; routing activities; parts and tools listing; and the building of a prototype or model of the product. The production planner then forwards his findings to a cost engineer or a cost accountant who will estimate the cost of manufacturing the product. In small furniture manufacturing firms, the estimates are usually furnished by the production managers or the product designers.

The cost estimates are then forwarded to the finance department in order that funds may be appropriated for the manufacture of the product. The list of material and parts requirements is sent to the storekeeper who subsequently reports to the purchasing department (under finance) on what materials and parts are out of stock and need to be procured. The purchasing department buys or otherwise procures the materials and parts needed. The agreed delivery date is passed on to the production control department which will be in charge of routing and scheduling the manufacture of the product. Dispatching activities in a small firm are usually handled by the production manager.

Notes

1/ Unless otherwise indicated, in this manual the term "small-scale" is used, for brevity, to cover family, small or medium-sized enterprises employing up to 100 people.

2/ Small-scale furniture manufacturing firms are assumed to develop in stages almost parallelling those in the life cycle of the product: introduction; growth; maturity; and decay. In some cases, an idea or conception stage precedes the introduction stage.

3/ One definition of specialization that has proved useful for small-scale industries has been the ability of a relatively small firm to concentrate on using its limited resources to produce as limited a product line as possible in areas where it has a distinct advantage. The degree of application of the concept of specialization may be measured using the following ratios:

$$\text{(a) Market specialization ratio} = \frac{\text{Sales generated by the market segment having the highest sales volume}}{\text{Total sales volume}}$$

$$\text{(b) Process specialization ratio} = \frac{\text{Sales generated by the process having the highest sales volume}}{\text{Total sales volume}}$$

(c) Product specialization ratio = $\frac{\text{Sales generated by the product having the highest sales volume}}{\text{Total sales volume}}$

The values of the specialization ratios may range from a high of 1.0 (indicating highly specialized firms) to 0. (See also Eduardo Q. Canela, "Making subcontracting work", Small Industry Journal, December 1981.)

4/ See Canela, loc. cit.

5/ Specific types of production management problems are touched upon elsewhere in this manual as follows: planning related problems, chaps. I-V and VIII; control-related problems, chaps. III, IV, VI-VIII; productivity-related problems, chaps. V-VII; organizing, directing and integrating related problems, chaps. I and VIII; and technology-related problems, chaps. I, V and VI.

6/ A simple sorting/classification technique, the Pareto Principle can be used with good effect in other areas of furniture manufacturing.

7/ Low Cost Automation for the Furniture and Joinery Industry (ID/154/Rev.1).

8/ The principles of motion economy and workplace layout and design have been taken from the International Labor Organisation, Introduction to Work Study, 3rd ed. (Geneva, 1979). Only those principles directly applicable to small-scale furniture manufacturing firms have been selected. Readers should refer to the ILO publication for the complete listing.

9/ These codes provide a rough guide as to which size or type of furniture manufacturing firm each principle is most likely to be applicable: A = Job-order, small to very small firms; B = Rigid-mass production or medium-sized firms; and C = fairly large-sized firms, probably using a flexible type massproduction system.

10/ Introduction to Work Study classifies the movements of the human body as follows (see p. 157).

Class	Pivot	Body members moved
1	Knuckle	Finger
2	Wrist	Hand and fingers
3	Elbow	Forearm, hand and fingers
4	Shoulder	Upper arm, forearm, hand and fingers
5	Trunk	Torso, upper arm, forearm, hand and fingers

11/ The specific technique used, known as "value analysis/value engineering", attempts to determine the cost-function relationship of the parts and materials used in a product. For a more detailed discussion, see: Lawrence D. Miles, Techniques of Value Analysis and Engineering, 2nd ed. (New York, McGraw-Hill, 1972) and Manual on Value Analysis (ID/298).

12/ For information on the statistical and monogram methods of determining the number of observations to be made, see Introduction to Work Study, pp. 196-198; for instructions on making random observations, see pp. 198-204.

13/ See Introduction to Work Study on the determination of sample size for time studies (p. 230). See also Raymond Mayer, Production and Operations Management, 3rd ed. (New York, McGraw-Hill, 1975), pp. 516 to 517).

14/ By a standard level of performance is meant the average output which qualified workers will naturally achieve, without over-exertion, in a working day or shift, provided they are familiar with and adhere to a specified method and are sufficiently motivated to apply themselves to their work.

15/ Introduction to Work Study, p. 249.

16/ Ibid., pp. 266 and 268. This publication also provides details on how to estimate their allowances.

17/ Manual on Value Analysis (ID/298); and Low Cost Automation for the Furniture and Joinery Industry (ID/154/Rev.1), prepared by W.J. Santiano and H.P. Brion.

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