SYSTEMS
AND INDUSTRIAL ENGINEERING SERIES

E-Enabled Operations Management

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ISTE
WILEY

Preface

Although the theory of operations management has been presented in many textbooks published over the last two decades, the subject of e-enabled operations management is rather short on literature which is easily accessible to students. When they want to gain some understanding of what it is all about, students are obliged to search journals and select papers from a large number of books. Even then they will find it difficult to arrive at a uniform view of the matter.

The objective of this book is to expound the subject at an “intermediate” level. By “intermediate”, it is not assumed that students are specialists in mathematics and statistics, but it is supposed they have a working knowledge of calculus, algebra, probability and statistics.

The approach to operations management described in this book is unusual with respect to what is found in standard textbooks. Information and communication technologies (ICTs) impact the ways firms are organized and managed, and, as a result, change the practical means used to conduct business operations.

The features of this book are threefold.

– *system approach to business modeling*

Business activities, controlling functions and associated information systems are described within a coherent analytical system framework enabling a clear understanding of the various current control and costing concepts. Operations costing is not usually included in textbooks as part of operations management, but it should

be. Cost targeting has become an integral part of good practice of business management.

– *validity of models*

Apparently simple models are analyzed in detail. Students must be completely aware of the assumptions made when models are formulated and of their conditions of validity. Applying a model automatically implies that assumptions of a particular type are taken for granted.

– *logistics, procurement and quality management*

These three business functions are critical key success factors for managing e-enabled supply chains from suppliers to customers. That is why their main tools are introduced in this book.

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May 2015

PART 1
Modeling of Business Structures

1
System Approach to Business Operations and Information Engineering

1.1. System approach to conduct business operations

1.1.1. *General considerations*

The system approach is instrumental in tackling complexity in the managerial as well as technical worlds. The system concept is a modeling tool based on interacting entities. Its purpose is to understand complex structures by (de)composing them into entities having specific functions and interacting with each other.

The “composition” approach is implemented when designing a real or virtual object. The “decomposition” approach is implemented when analyzing some existing part of the world.

In both approaches, systems are constructed with a view to identifying certain function capabilities perceived by the users to be desirable. Examples of function-based systems include: defending the country, transmitting messages, transporting people and goods, manufacturing goods, exchanging products and services, etc.

In general, users are known not to be able to articulate all their requirements and expectations. Therefore, at the planning stage, there always exists a considerable uncertainty about many aspects of the system to be built, or, in other words, the system behavior. That explains why

prototypes have to be built for checking whether the users' requirements are adequately fulfilled.

Systems do not exist in isolation. Each operates within a definite environment. But the ways a system interacts with its environment may prove to be of a wide variety. In other words, how and when some types of interaction take place have to be ascribed to uncertain or random events. As a result in certain circumstances, the system behavior can run out of control. These circumstances refer to events or sequences of events which have not been taken into account at the design stage of the system.

1.1.2. System description

Describing a system implies:

– describing its constituent entities as attributes;

– describing the inter-entity relationships;

– describing the relationships between entities and the environment.

Each entity can be a system in itself.

When a business unit is described as a system, the purpose is to control its business operations. Three entities have to be identified, i.e. the controlled system, the controlling system and the information system (IS). The controlled system, often called the transformation system, because it converts inputs into outputs, is modeled generally as a process. The relationships between these three entities are shown in Figure 1.1.

It is noteworthy to elaborate on Figure 1.1 for understanding the features of the system approach to business description. What is meant by direct and indirect control? Direct control refers to the direct action on the

controlled process to maintain or change its state. Indirect control resorts to some entity external to the system for influencing the state of the controlled process by means of inputs.

Let us take an example to explain how the messages exchanged between the entities involved are articulated and how their contents trigger decisions. The controlled process is assumed to be a manufacturing process made of storage and production activities. A message coming from the market place (environment data) is captured and processed by the IS. The message content says that a market slump is forecast. It is directed to the production scheduler in an appropriate format (control data). As a consequence, the scheduler decides to reduce the production level by releasing orders to the manufacturing shops (direct control) on the basis of inventory levels (process data) and to send orders to suppliers to decrease the number of deliveries (indirect control).

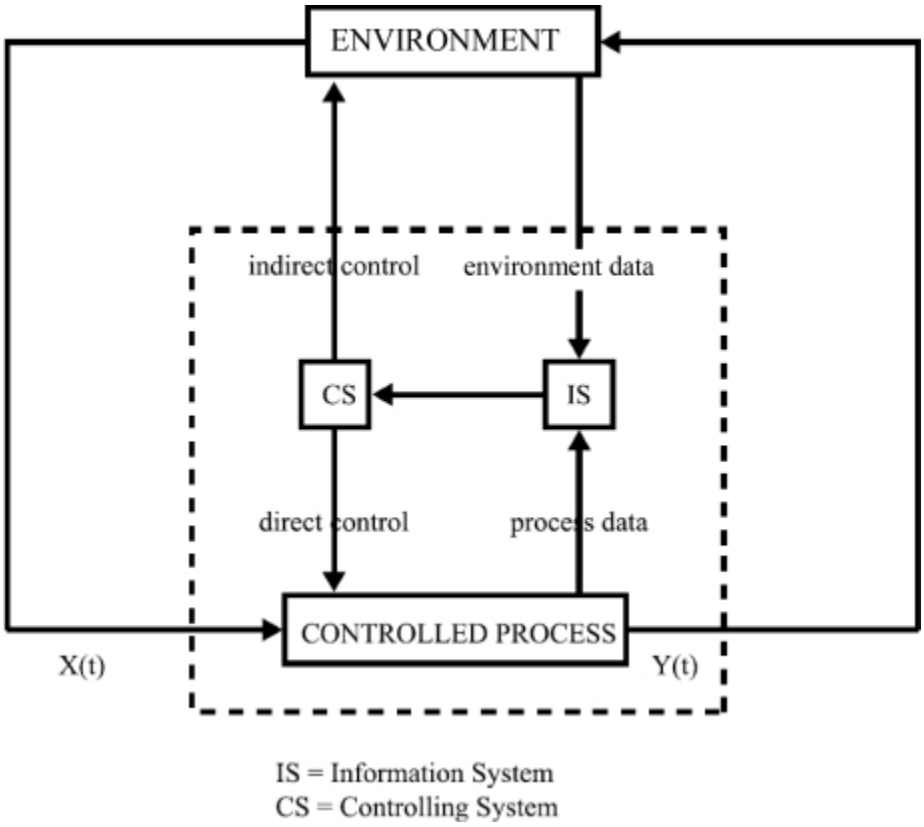

Figure 1.1. *Relationships between the various entities of a business unit within the framework of a system approach*

Describing any business organization as a system means:

– identifying and modeling the system to be controlled (WHAT);

– identifying decision-making functions (WHO) and defining management rules (HOW);

– producing the IS requirement.

1.2. Information engineering

1.2.1. *Information as a resource*

Central to any human activity is the process of *decision-making*, i.e.:

– defining a goal;

– identifying a number of alternative *actions* which may lead to the goal;

– evaluating the consequences of each action;

– selecting the action which is most likely to lead to the desired goal.

The decision maker, in general, faces uncertainty mainly about the results of the envisaged action. Decisions vary in uncertainty associated with their outcomes. The greater the uncertainty, the greater the risk of a negative outcome. This uncertainty can be reduced or even completely removed by obtaining the relevant information about the courses of action in progress. It follows that information is defined as a resource by means of which uncertainty is reduced.

For large systems, as a rule, a part of the required information on the behavior of system environment becomes available only after the system has been put in operation. For this reason, there is a need for incorporating a control function of a sort into the very system. The role of control is to make decisions on the system behavior effective. When some deviation from the set goals is detected corrective control action is engineered to reach the set goals.

1.2.2. *Explicit and implicit information*

Information may be explicit or implicit. Implicit information or knowhow is that piece of information which is an integral part of skill and can be gained only by apprenticeship from an expert. The term “expert” is used

here to denote a person who knows how to perform an activity without necessarily understanding why his/her methods work. In contrast, explicit information or know-how exists independently from any skill. It can be readily represented, stored and made available for general use.

1.2.3. *Clarification of some terms*

The body of knowledge, methods and established practices related to the handling of information as well as the associated devices will be called *information technology.* Systems of artifacts, the purpose of which is to handle information will be called here *information systems*. The engineering discipline concerned with the design, production, installation, operation and maintenance of ISs will be called *information engineering*.

1.2.4. *Characteristics of information systems*

It is quite clear that no organization could operate without some type of IS. The main functional capabilities an IS must fulfill are:

– capturing data;

– processing data;

– memorizing data.

These are followed in order to support the decision makers to conduct business operations.

– *Contents of an information system*

Even if users are not aware of this fact, IS designers posit that ISs are a modeled vision of the business universe. Whatever the assumptions made about the chosen representation of the business universe, IS constructs reflect how the enterprise is organized and operates. It

implies that business information systems contain, in a way or another, a description of the enterprise's organizational structures, functioning mechanisms and deliverables. The contents of business information system include:

– static properties of operations and controls;

– description of deliverables (products or services);

– dynamic behavior of operations.

Several types of ISs are considered in businesses.

– *Transaction processing systems*

A transaction is a business operation modifying the state of the enterprise. Whenever a transaction occurs, data describing the transaction is created. Capturing, storing, processing, distributing and reporting of transaction data is the objective of transaction processing systems.

Let us consider an example. When a client places an order, an order form is created where the order content is described in terms of items, quantities and delivery dates and payment conditions. This order triggers updating of the inventory, sending an invoice, launching the manufacturing of new items, recording provisional income in the balance sheet, etc.

Somehow transaction processing systems are the front office of management information systems (MISs)

– *Management information systems*

MISs must give a relevant, accurate, significant and updated image of business activities and incoming and outcoming goods flows. Today, this is achieved by means of artifacts (software programs and databases) modeling the activities and goods flows involved.

1.2.5. *Information system content for a manufacturing company*

The IS content comprises the models representing the business from different points of view (processes/functions/organization). As an example, the products/services delivered, the control pattern and the infrastructure can be modeled for a manufacturing company as shown in Figure 1.2.

1.3. System approach to describing inventory-controlled storage

Storage is a buffer activity decoupling inflows of materials from outflows. Materials consist of raw materials, finished products, goods in progress and any type of supplies held by business firms. Inflows and outflows are usually controlled by different business functions.

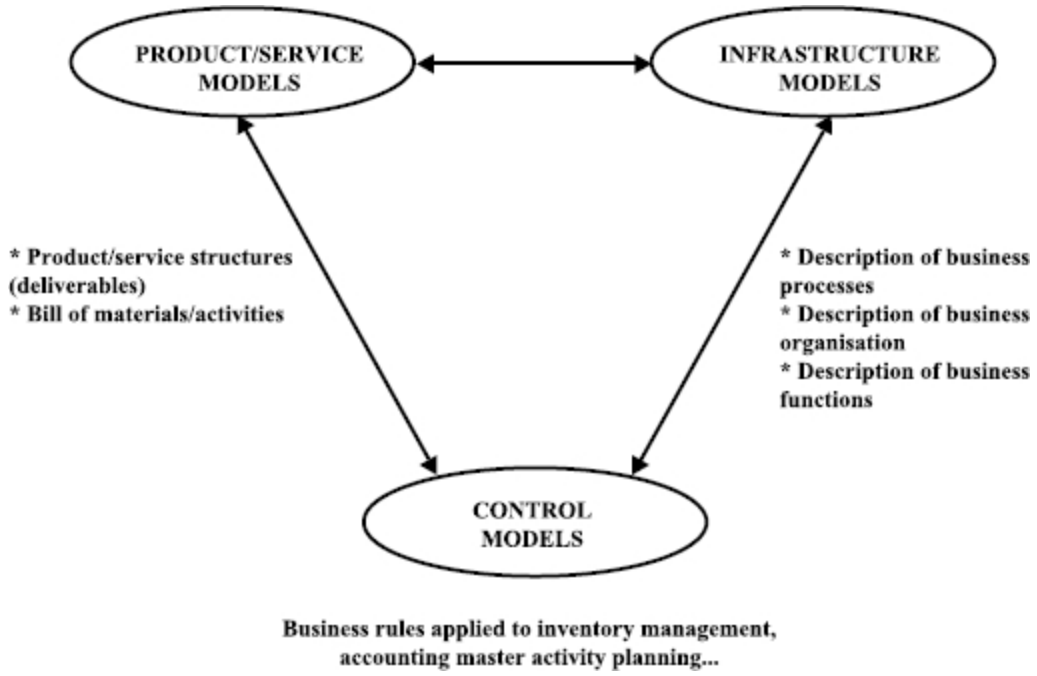

Figure 1.2. *Content of an information system for a manufacturing company*

Despite costs incurred when holding stocks, multiple motives to carry inventories justify their presence in businesses.

– *Cover of stockout situations*

If suppliers are not reliable, buffer stocks facilitate clients to be provided with the materials they require on time. In other words, it ensures a chosen service level of deliveries to clients. At the same time, if demand is stochastic it gives the possibility of sustained deliveries to clients over a period of time within limits derived from the chosen service level.

– *Economies of scale in supply*

When orders of large quantity are placed, reduced prices are obtained (quantity discount) and some fixed costs (transportation, ordering costs) are portioned out to a larger quantity reducing the unit cost as a consequence.

Consider a storage activity receiving raw materials from suppliers and dispatching them to manufacturing shops when called off.

– Identify the sequence of activities from suppliers to the manufacturing shops.

– Identify the controlling functions.

– Describe the requirements of the associated information system.

The safest procedure to identify the sequence of activities involved is to follow the goods flow from suppliers to clients (here the manufacturing shops). In this case under consideration, three sequenced activities are identified, i.e. receiving, storage and distribution to manufacturing shops.

The controlling functions are found by answering this question: who triggers the activities? The receiving unit becomes active because the procurement function has released delivery orders to suppliers. The distribution unit becomes active when the manufacturing scheduler releases requisition lists of materials to be picked up from storage and delivered to the manufacturing shops.

It is worth noticing that inflows of materials are controlled by the procurement function whereas outflows are controlled by the production scheduling function. This feature stresses the decoupling role of storage.

Inflow and outflow transactions have to be recorded by the IS so that the on-hand inventory for each material is known at every moment. It is assumed that inflows are controlled with the inventory control system (ICS) concept. When the on-hand inventory level comes to a threshold, a replenishment order is released. The reorder level depends on the replenishment lead time and the depletion rate. In fact, it is the demand size during lead time.

The whole system is described in Figure 1.3.

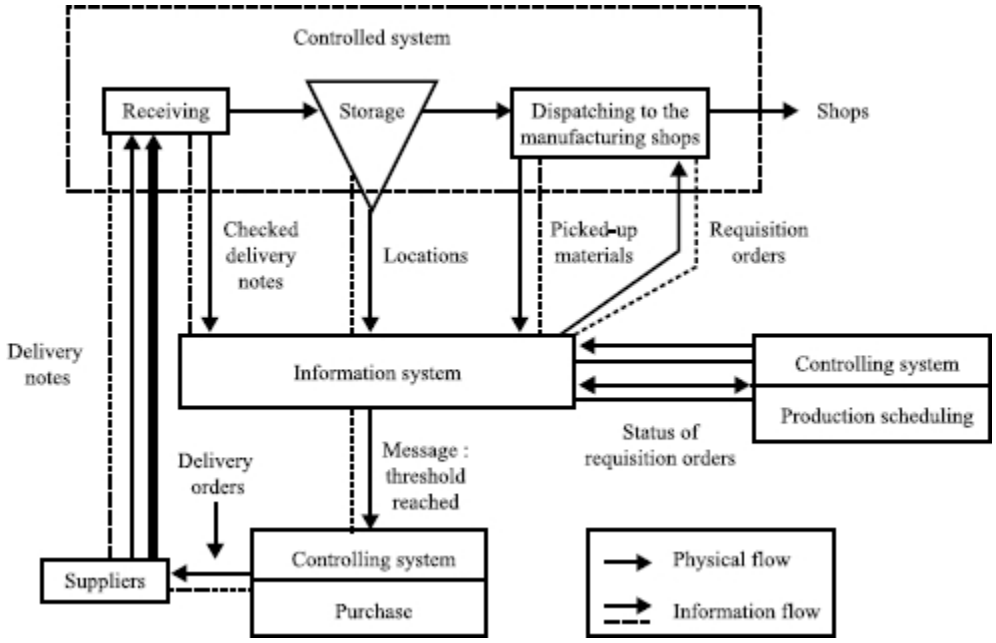

Figure 1.3. *System description of an inventory-controlled storage*

2
Business Modeling by Process and Management Applications

2.1. Process definition and control

2.1.1. *Definition*

Process has a Latin origin “processus” meaning “having progressed”. It strongly connotes the dynamics of tasks. It was widely used to describe non-stop manufacturing industries such as steel mills, glass mills, oil refineries, etc.

The use of this wording in the management arena is now widespread. In order to avoid any misunderstanding, definitions have been given by standardization bodies or other institutions and will be commented on hereafter.

A process is a set of means and activities converting input into output (ISO 8402 and 9004).

A definition was given by IBM in an in-house journal of IBM research center at La Gaude/France in 1987 and provides a telling insight. It can be summarized as follows.

A process is a chain of tasks performed to yield a final product/service. It is modeled by a sequence of activities characterized by:

– measurable inputs;

– value added;

– measurable outputs;

– repetitive running.

Any process must yield a product/service

Any product/service is the outcome of a process

The purpose of process management is to bring process operations under full control, to make them more efficient (productivity) while improving the output (quality).

2.1.2. *Process control mechanisms*

Once a process has been designed and implemented and its operational objectives assigned, controlling how it performs is the main focus. Two types of process control mechanism derived from automation, i.e. feed-forward and feedback can be put in operation. In practice, they are combined to achieve the full control of the process under consideration.

The feed-forward control mechanism can be described in this way. A sensor located on the input flow of a primary business process detects an event and sends a reporting signal to the controlling function. As a result, instructions are issued to make the primary process capable to deal with the incoming flow in the most efficient way. Figure 2.1

exemplifies the mechanism in the case of goods receipt from suppliers.

The feedback control mechanism is intended to let know to the controlling function whether a released order has been fulfilled or not. A sensor located on the output flow of a primary business process sends a reporting signal to the controlling function. In case a deviation with respect to the set objective is detected, a corrective action is triggered to meet the requirements of the set objective. Figure 2.2 exemplifies the mechanism in the case of work orders to be carried out by manufacturing shops. These orders include a quantity of products to deliver at a due date.

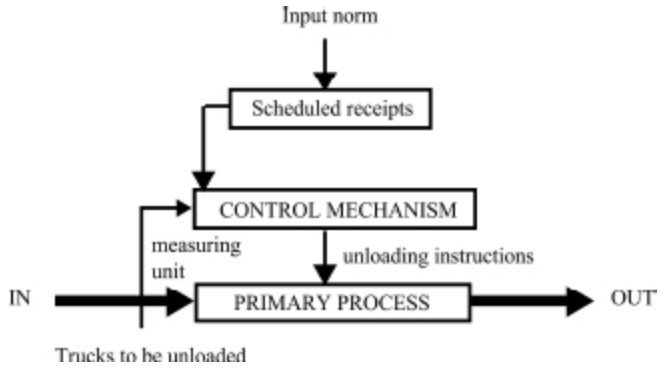

Figure 2.1. *Example of feed-forward control when incoming trucks bring deliveries from suppliers*

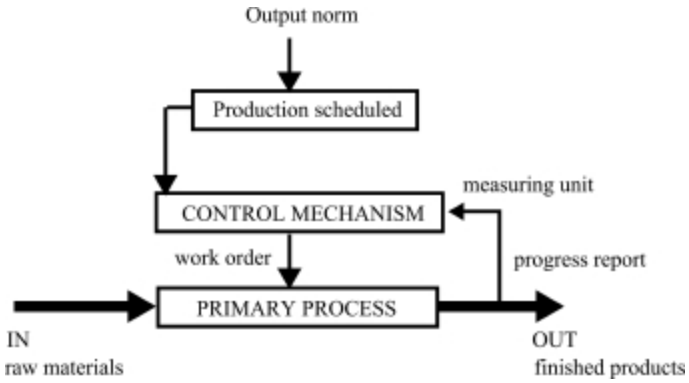

Figure 2.2. *Example of feedback control in a manufacturing process converting raw materials into finished products*

When the system concept is called upon in the management sphere, the only control mechanism referred to is *feedback control.*

In fact, the feed-forward mechanism is operative whenever scheduling takes place.

2.2. Process modeling in perspective

2.2.1. *General considerations*

The concept “process” is evolved as a modeling tool. It is not in competition with the system approach and may complement it in a very useful way.

The system approach focuses on identifying interacting entities for reaching an understanding of complexity. Breaking down a whole into pieces allows studying each piece independently from others with the proviso that the influence of other interacting pieces is incorporated into its behavioral attributes.

When sequencing the entities of a decomposed system is required for whatever reason, process modeling is the right implement. Several more or less sophisticated formalisms can be used. Each has its advantages and disadvantages: we should never forget that process modeling and modeling in general, are a means of communication and which does not make them vernacular.

System and process concepts can be tied together to produce a relevant framework for representing business entities. It will be elaborated later as “business models”. How system and process concepts complement each other is shown in Figure 2.3.

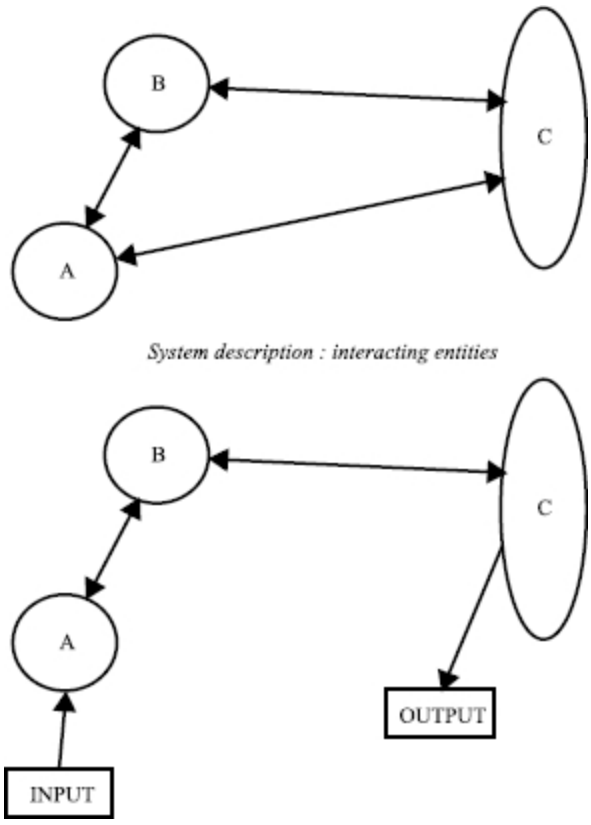

Figure 2.3. *Comparing system and process concepts*

For example, a car is a complex system; several processes can be identified inside this complex system, i.e. the propulsion process, the braking process, the driving process, etc.

A model is a representation of a part of the world, built from a certain point of view to serve a purpose.

This definition induces the fact that the same part of the world can be represented by different models depending on the purposes to serve. For example, a personal computer can be represented by different models as a function of the possible points of view: manufacturing, maintenance, software developers, end users, etc.

2.2.2. *Management applications*

2.2.2.1. *Introduction*

Process modeling is already widely used for management applications. The various domains of application in the management context are the value chain concept, information system design, supply and demand chain management and control of activities as shown in Figure 2.4.

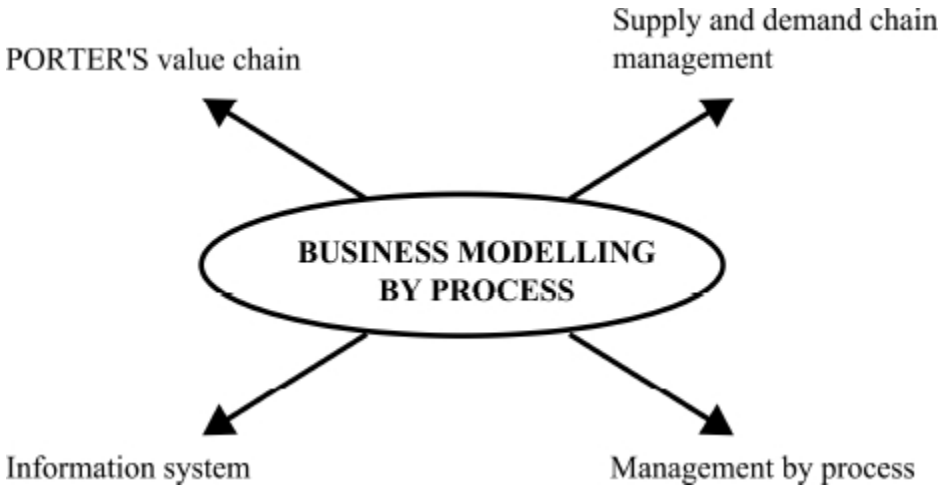

Figure 2.4. *Domains of application of business modeling by process*

2.2.2.2. *Supply and demand chain management*

The supply chain is a set of processes taking input from suppliers, adding value and producing output for clients.

The concept of supply chain management is described as an integrated approach to planning and controlling the whole goods flow through a network of suppliers, factory sites, warehouses, distribution centers, retailers to end users. The key role played by logistics is portrayed in Figure 2.5.

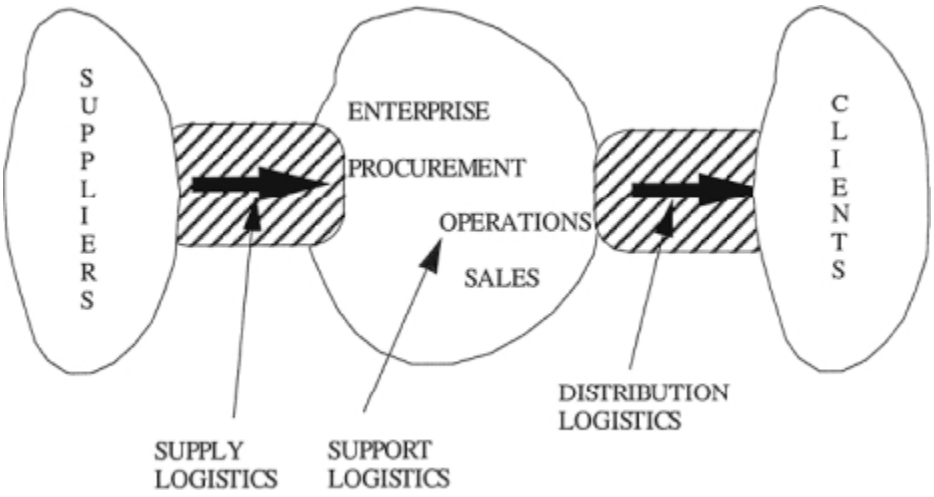

Figure 2.5. *Supply chain process from suppliers to clients and the key role of logistics*

When the focus is put on the control side, the wording "supply chain process" and "demand chain process" can be used to distinguish the push mechanism from the pull mechanism, both triggering the chained activities of the supply process.

Supply and demand chain management focuses on customer satisfaction. From this angle, business modeling by process has the following advantages which justify this choice:

– it allows the focus to be put on the business deliverables (products/services) to customers. They are the true purpose of any business and unavoidable market partners;

– it allows us to understand how a process is performed by describing its activities and their relationships to yield deliverables. Such a "transparency" of business operations helps us to give a clear picture how actual activities and tasks are realized and how they can be improved to achieve the output of deliverables to meet customer demands in terms of *quality, delivery time* and *cost*.

2.2.2.3. *Porter's value chain*

The value chain concept is a tool for examining a firm's activities and the way they interact, enabling the analysis of the sources of margin and competitive advantages.

Activities are interdependent building blocks with which a firm creates a product/service valuable to its buyers. They are configured in processes as shown in Figure 2.6.

Figure 2.6. *Value chain process introduced by Porter*

The economic performance is globally measured by the profit margin. It is the difference between the turn-over generated by the sales (i.e. the price customers are willing to pay) and the costs incurred by performing the activities. Through value analysis Porter's business model is supposed to enable assessing how an activity interacting with others can increase its contribution to the process profit margin. The key activities can be identified by their relatively large contribution.

2.3. Management by process

In the paradigm of management by process, a systematic, structured approach is set to analyze, improve, control and manage the work activities configured into processes. This approach, to the study of processes, has received various labels such as "process simplification", "process

improvement”, and “(re)engineering” covering bottom-up as well as top-down methods.

Activity-based process modeling can then be used for various management purposes:

– activity-based costing (ABC) and budgeting of products/services;

– activity-based management.

2.3.1. *Activity-based costing and budgeting of products/services*

2.3.1.1. *Shortcomings of the traditional cost model and features of the activity-based approach*

The traditional cost model distorts product/service cost for several reasons:

– Overhead costs are often apportioned rather than traced to cost objects (products/services). The apportionment rate has in many cases no “rational” basis and is chosen for a matter of convenience.

– As the overhead component of costs has become a larger percentage of total costs, the cost distortion induced by the apportionment key produces increasingly non-accurate figures.

When the management wants to take action for reducing costs, the traditional cost model does not provide the right information tracing back the sources of overhead costs. Somehow the management is blind. The activity-based approach has been developed to resolve these shortcomings.

In activity-based accounting, resources are consumed in the execution of activities. Products/services consume

activities and materials. Emphasis is put on determining the cost of support activities that are labeled “overheads”. Activities are clearly linked with their causes, i.e. the consumptions of resources. The tracing of activities to products/services reduces, as much as possible, the amount of overheads to be apportioned to products/services.

This approach aims at establishing cause-and-effect relationships between an activity and its output and between an activity and the resources consumed to make this activity instrumental. This results in a focus on causes of cost allowing for traceability.

2.3.1.2. *Some words clarified tasks-activity-process*

A task is a piece of work to be carried out.

An activity is a set of tasks assigned to a person/machine or a group of persons/machines and aimed at achieving an objective.

A process is a chain of activities triggered by a common signal and designed to produce a specific result as products or services.

The relationship between task, activity and process is shown in Figure 2.7.

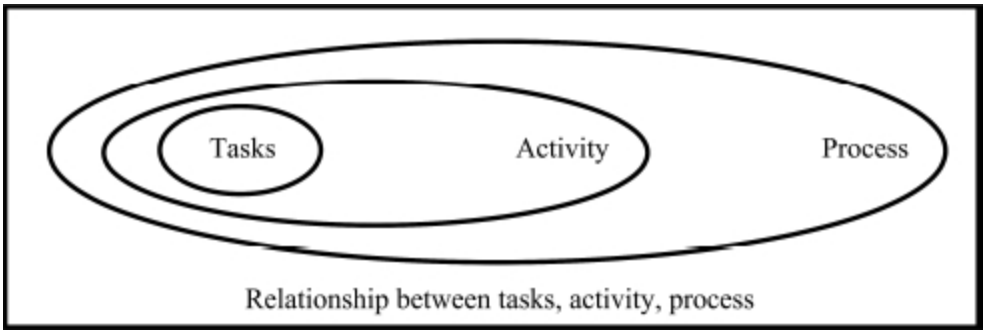

Figure 2.7. *Relationship between task, activity and process*

Delineation between process and activity is not always clear-cut and is somewhat arbitrary. Here are some commonplace criteria to distinguish between processes and activities:

– a process can aggregate several activities controlled by different departments (matrix organization);

– a process can be viewed as a chain reaction of interrelated activities triggered by an external event (complaints office);

– a process can be considered as chained activities organized to reach a goal (market- or product-oriented organization, retailing channels, etc.);

– a process has always an input and an output and can be defined in relation to its suppliers and customers.

Drivers

The term “cost driver” has been used for quite a while and its spreading usage is closely associated with the dissemination of ABC. However, there has been little consistency over what is meant by the term. R. Cooper coined the term *first stage cost driver* as a way of transferring costs from a general ledger line item to an activity cost and the term *second stage cost driver* to get the activity cost onto the cost object.

This approach reflects an accounting type of influence and is exemplified in Figure 2.8.

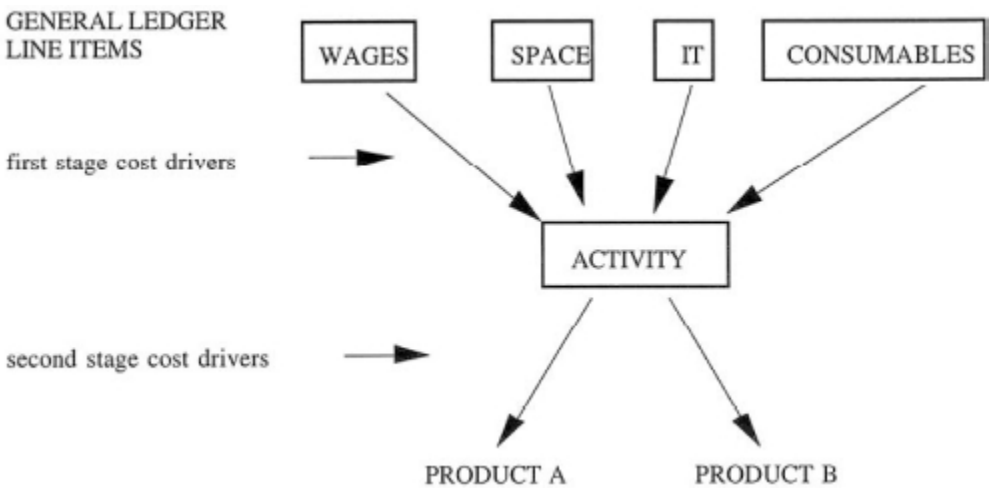

Figure 2.8. *Mapping of general ledger line items onto cost objects*

The difference between *first stage cost drivers* and *second stage cost drivers* has other dimensions to be taken into account by two types of factors:

– factors which trigger resources to be consumed when an activity or a chain of activities (process) takes place and as a consequence cause a cost to occur;

– factors which cause an activity to operate frequently so as to achieve an objective.

The first types of factors are used to improve process effectiveness and efficiency. The second types of factors are linked up with operating practices.

Cost ascertainment of products/services must warrant that unit costing mirrors actual operational costs as closely as possible.

Whatever wording is used, the central issue after decomposing an organization into activities is to choose a pertinent variable (cost driver) in order to apportion activity costs to outcoming product/service units. The

important point is to know and make known what you are talking about.

2.3.1.3. *Principles*

Activity analysis has to be undertaken to produce a base line of building blocks defining tasks and resources consumed, allowing for processes to be easily established and visibly reflecting for what and how outputs are worked out.

A five-step procedure can be used:

– identify activities;

– portion out to activities the resources consumed;

– aggregate granular activities into manageable activity pools;

– list objects (products/services) to be cost;

– allocate pools' costs to cost objects.

This approach can be denominated as a top-down or forward one, i.e. assessing causes (resources/activities) producing effects (output).

Another approach has been proposed for costing mass-customized service operations in a public utility. Within this context, indirect resources are first traced forward to the direct resources consumed, the latter being traced forward to basic activities classified in service components. It is referred to a customized chain of component services to frame a customized service and trace back the cost of providing this specific service.

A schematic diagram of this mechanism is shown in Figure 2.9.

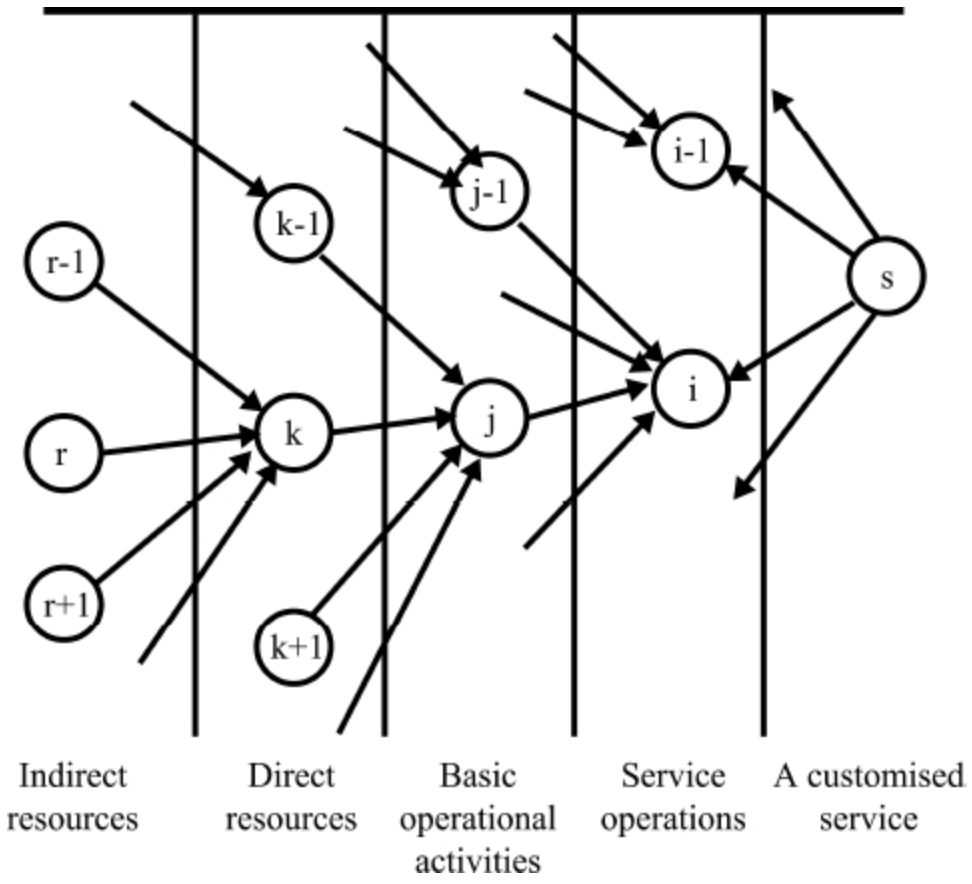

Figure 2.9. *Backward approach to costing customized services by finding out the causes (resources) from observable effects (services)*

This approach can be termed as a bottom-up or backward approach, i.e. finding out causes (resources) from observable effects (services).

EXAMPLE.– Contrasting a traditional costing method with an activity-based costing.

Figures 2.10. and 2.11 contrast a traditional costing method with an ABC approach for the same product. The difference in total cost can be explained by the fact that a more meaningful cost model reflecting the real-consumption of resources is provided. From a computational point of view overheads are “converted” into direct costs.

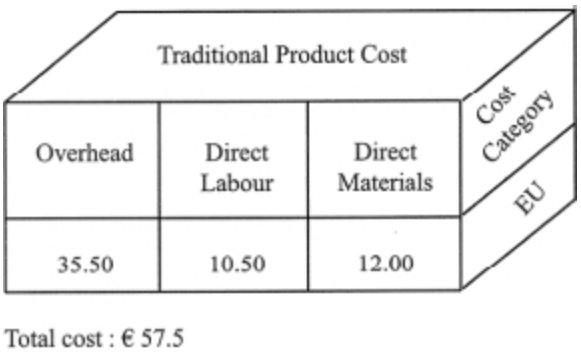

Figure 2.10. *The traditional product cost*

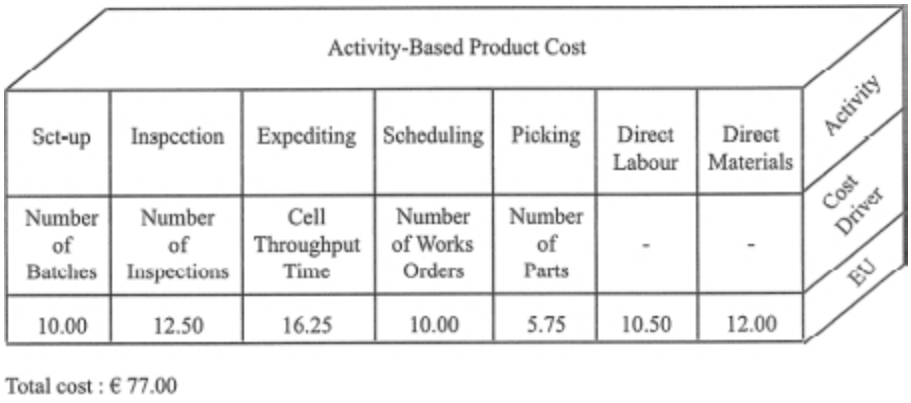

Figure 2.11. *A typical activity-based product cost*

Let us explain the details of the two computational models. Consider a production line manufacturing two types of products A and B. The cost price of A is to be ascertained.

The materials costs and labor costs incurred by both manufacturing processes can be easily controlled and traced to the two products without major problem. Incurred costs common to the two manufacturing processes (overhead) have to be divided among the two cost objects:

– The traditional approach makes use of cost centers and rates: their choice is based more often on criteria of convenience than on conformance with facts. The approach is shown in Figure 2.12.