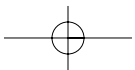
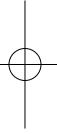
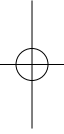


# The Operations Function



# Operations

***Operations Management is the business function dealing with the management of all the processes directly involved with the provision of goods and services to customers.***

## OPERATIONS MANAGEMENT AS A DISCIPLINE

Operations management is both an academic discipline and a professional occupation. It is generally classified as a subset of business studies but its intellectual heritage is divided. On the one hand, a lot of operations management concepts are inherited from management practice. On the other hand, other concepts in operations management are inherited from engineering, and more especially, industrial engineering.

Neither management nor industrial engineering is recognised as a 'pure science' and both are often viewed as pragmatic, hands-on fields of applied study. This often results in the image of operations management as a low-brow discipline and a technical subject. Meredith (2001: 297) recognises this when he writes that *'in spite of the somewhat-glorious history of operations, we are perceived as drab, mundane, hard, dirty, not respected, out of date, low-paid, something one's father does, and other such negative characteristics'*.

This is not a flattering statement, but it is worth moderating it quickly by the fact that economic development, economic success, and economic stability seem to go hand in hand with the mastery of operations management. Operations management is an Anglo-Saxon concept which has spread effectively throughout many cultures, but has often failed to diffuse into others. For example, there is no exact translation of the term 'operations management' in French, or at least, not one that is readily agreed upon. This is not to say that French organisations do not manage operations: the lack of a direct translation may be due to the fact that the operations function 'belongs' to engineers rather than managers in French culture. In other cultures, however, the very idea that one should manage operations may not be a concern. For example, it is not unusual in some countries to have to queue for two hours or more to deposit a cheque in a bank, whereas other countries will have stringent specifications

requiring immediate management attention if a customer has to wait more than five minutes.

If indeed the mastery of operations management is associated with economic success, this means that despite its potential image problems operations management as a practice may play a fundamental role in society. As acknowledged by Schmenner and Swink (1998), operations management as a field has been too harsh on itself as it both informs and complements economic theories (see **Theory**).

## WHY OPERATIONS MANAGEMENT?

### A theory of operations management

The purpose of a theory of operations is to explain:

- why operations management exists;
- the boundaries of operations management;
- what operations management consists of.

Note that the concept of operations predates the concept of operations management. Hunters and gatherers, soldiers, slaves and craftsmen have throughout human history engaged in 'operations', i.e. the harvest, transformation, or manipulation of objects, feelings and beliefs. Operations management, as we know it today, is an *organisational* function: it only exists and has meaning when considered in the context of the function that it serves within a firm or an institution. Thus, in order to propose a theory of operations management we first need to ask ourselves – 'Why do firms exist?'

In a Nobel-prize winning essay in 1937, Richard Coase explained how firms are created and preferred as a form of economic organisation over specialist exchange economies. The key tenet of Coase's theory is that the firm prevails under conditions of marketing uncertainty. It is because of the fear of not finding a buyer, of not convincing the buyer to buy, or of failing to match the buyer's expectations that an individual economic actor is exposed to marketing risk. When uncertainty exists, individuals will prefer to specialise and to 'join forces', seeking synergistic effects in order to cope with uncertainty.

Figure 1.1 below builds on Coase's theory and proposes a theory of operations management. It shows that individuals seeking wealth are discouraged from working independently because of marketing risks. In

order to reduce their exposure to uncertainty, they will prefer to enter into a collaborative agreement to pool risks in large organisational systems, thereby capturing a broad range of complementary specialist skills. The rationale for this behaviour is that it pays to concentrate on what one is good at: a specialist will be more effective at executing a task than a non specialist. *Specialisation* was the major driver during the Industrial Revolution along with technological innovation. Specialisation patterns are commonly described through the theory of the *division of labour*.

### The division of labour

The division of labour is a concept which can be analysed at several levels. When you wonder about whether to become a doctor, an engineer or a farmer, this choice of a specialist profession represents the *social division of labour* at work. The emergence of firms has resulted in the further specialisation of individuals with the *technical division of labour*.

To understand what the technical division of labour implies, consider the example of a craftsman assembling a car before 1900. Without the assistance of modern power tools, of automation, and of technological innovations such as interchangeable parts, building one car could require up to two years to complete. The craftsman was not only a manual worker but also an engineer: he knew perfectly the working principle of an internal combustion engine and what each part's functions were. In a modern assembly factory today, it is not unusual for a car to be assembled from scratch in about nine hours by workers who know very little about automotive engineering. This incredible gain of efficiency is the result of the technical division of labour.

In 1776 Adam Smith published his treatise 'An Inquiry into the Nature and Causes of the Wealth of Nations', which is often regarded as one of the first business theory books ever written. Adam Smith was a pioneer in documenting how the division of labour would result in considerable productivity gains. Note that his contribution was only to *observe* that the division of labour was a major factor explaining why some firms and societies were wealthier than others. In other words, Adam Smith documented that such wealth seemed to stem from specialisation. The individuals who transformed the concept of division of labour into management principles were Charles Babbage and Frederick Taylor.

Babbage's intellectual contribution in 1835 was to build on Smith's observations and to highlight the benefits of the *horizontal division of labour*. The horizontal division of labour requires dividing tasks into

key concepts in anti-discriminatory social work

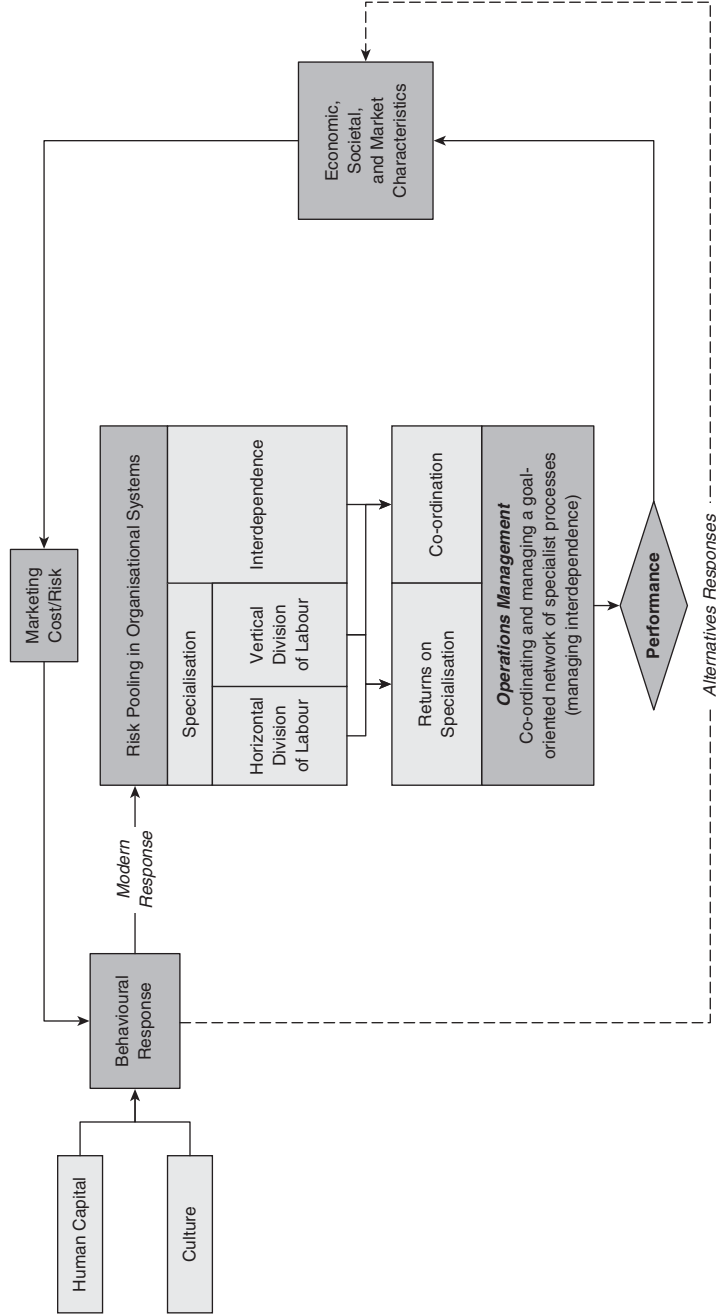


Figure 1.1 Theory of operations management

smaller and smaller sub-tasks. To be more productive, to generate more wealth, one should simplify jobs to their most simple expression.

Frederick Taylor, the author of *Scientific Management* (1911), went one step further. His theory was that effective operations in a business could only be achieved if work was studied scientifically. Taylor's contribution to management was the introduction of the *vertical division of labour*. This principle implies that the individual (or unit) who designs a job is usually not the individual (or unit) who implements it. This gave birth to a new field of business studies, called *work design* (see **Wock**), which was the ancestor of modern **process management**.

### Theory of the division of labour

Although the division of labour was for a long while not considered a theory, both the overwhelming evidence of its existence and recent economic research show that economists may one day finalise the formalisation of a theory of division of labour (Yang and Ng, 1993). Although this constitutes ongoing research, it is possible to speculate on what the fundamental laws of this theory are:

- *Law of specialisation*: In order to mitigate risk and to benefit from synergistic system effects, firms specialise tasks. It pays to concentrate on what one is good at. Increased specialisation tends to lead to increased performance levels.
- *Law of learning and experience curves*: The repetition of a task is associated with increasing efficiency at performing that task (see **Learning Curves**).
- *Law of technology*: Technology can be used to further increase the efficiency of specialised tasks (see **Technology**).
- *Law of waste reduction*: The refinement of an operations process results in the streaming of this process into a lean, non-wasteful production process (see **Lean**).
- *Law of improved quality*: Specialisation results in the ability to produce a better quality job (as the division of labour requires individuals to concentrate on what they are good at, it is easier to become better at a specialist task and to avoid performing poorly on peripheral tasks).

### Interdependence

Specialisation, however, comes at a price. An individual economic actor will only depend on himself or herself for success. In a firm, though, specialist

A relies on specialist B, and vice versa. In such a work context, the potential size of operations systems raises questions about feasibility. When assembling cars, how do you make sure that every single part and component needed is available in the inventory? How do you make sure that every worker knows what to do and how to do it? When running a restaurant, how do you ensure that you keep a fresh supply of all the ingredients required by your chef, given the fact that ordered items will only be known at the last minute? And how do you make sure that everybody is served quickly?

In other words, 'joining forces' in the pursuit of wealth is easier said than done. With the shift of work from individuals (craftsmen) to specialist networks, each process and task has been simplified or specialised, but their overall co-ordination has become more difficult. This trend is still taking place today, for example, with the distribution of manufacturing and service facilities across countries to take advantage of locational advantages (the *international division of labour*). Excellent co-ordination is a fundamental requirement of operations system, as individuals have – in exchange for reducing their exposure to risks – replaced independence with mutual dependence, or *interdependence*.

Interdependence is why we need operations management. Without operations management, inventory shortages, delays and a lack of communication between design and manufacturing would mean that a firm would never be able to convert risk pooling and specialisation into profits.

- *Law of managed interdependence*: The higher the interdependence of tasks, the higher the risk of organisational or system failure. This risk can be mitigated, hedged or eliminated altogether through co-ordination processes. Different types of interdependence require different types of co-ordination processes (see **Co-ordination**).

In a specialised firm, the application of the vertical division of labour means that a restricted set of employees, called the *technostructure* by Mintzberg, is in charge of designing operations systems and supporting planning and control activities.

### Return on specialisation

Today's economies, and therefore most of our daily lives, take place within the context of specialisation and the resulting need for trade and exchange. How specialisation works is the domain of many economic theories, such as the theory of absolute advantage and the theory of comparative advantage.



How specialisation, exchange and trade work together is the domain of much research on macro and international economics.

From an operations management perspective, it is important to appreciate fully the central role of specialisation. Operations management is nothing other than the 'art' or 'science' of making specialisation patterns work. The law of specialisation states that increased specialisation results in an increased performance level. Like most laws, this statement should be considered carefully: it is only under specific conditions that specialisation will lead to such performance benefits. To better appreciate these conditions, it is a good idea to consider the possible benefits and disadvantages of specialisation.

## The benefits of specialisation

These are:

- Increased performance and efficiency.
- Increased quality.
- Learning curves.
- Waste reduction.
- Improvement opportunities: as a specialist focuses on one task only, it is easier for this specialist to discover and implement improvements to a process.
- Sense of professional pride.
- High job motivation.

## The limits of specialisation

These are:

- *Low job motivation*: Intense specialisation may reduce a job to insignificant tasks. This results in low motivation, and potentially absenteeism and turnover. Practices such as job rotation and job enrichment are used to enrich jobs in order to diminish the negative impacts of specialisation in highly repetitive job environments.
- *Role ambiguity and conflicts*: Jobs can become so specialised that most people do not understand, and value, the job of a specialist. The exact nature of the job is misunderstood and conflicts of various types can then appear in the workplace because of misconceptions about 'what one does'.
- *Entrenchment*: The division of labour may create entrenched values in the workplace. For example, a quality manager will be overly committed to the quality mission whilst the production manager will be

overly committed to productivity targets. If each could better appreciate the task of the other specialist, co-ordination and collaboration between them would be easier.

- *Dependence*: Specialists depend on one another in terms of the quality of the final output. In the extreme case of organisational sabotage, specialists can purposefully reduce or modify their inputs in order to 'hurt' another specialist or the customer. There are complex responsibility patterns within specialist networks.
- *Co-ordination needs*: There is a need for synchronisation and co-ordination in the specialist firm. This does not come for free.
- *Traceability*: Given the number of individuals involved with production, it may be difficult to trace back the source of a problem. Poor traceability hampers the ability to improve processes and quality.

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## System

***An operations system is an objective-oriented network of specialist processes through which a collection of inputs are transformed into higher-value output. (Adapted from Hopp and Spearman, 2000)***

## SYSTEM THEORY

In the 1940s, the biologist Ludwig von Bertalanffy was critical of the predominant use of reductionism in science. The reductionist approach means that to understand a phenomenon one should isolate and study

individual characteristics of the elementary parts or components causing this phenomenon. For example, to understand medicine, one should study how the cells of the body function.

Von Bertalanffy stressed that real systems interact with an environment and that this open form of interaction induces consequences which cannot be modelled and understood within a reductionist approach. He also suggested that system theory – the idea of studying whole systems and how these interact with their environments – was a common task for a unified science, which he called *system science*. For example, biology, medicine, engineering, control, and economics researchers all use system theory nowadays. Further contributors to the development of system theory were Ross Ashby (cybernetics, in 1956) and Jay Forrester from MIT (system thinking, or system dynamics, also in 1956).

## SYSTEMS AND THEIR CHARACTERISTICS

A *system* is a set of parts connected together for a specific end. Each part of the system is one of the necessary means to achieving that end. In the case of an operations systems, the parts are the different specialist processes which are networked together to provide a good or a service according to customers' specifications.

Systems have a number of important properties:

- *Parts synergy*: A system is more than a mere accumulation of parts. Most of the value of the system resides in the seamless integration of the different parts. In other words, the whole is greater than the sum of the parts.
- *Behaviour*: A system exhibits behaviours which are the result of the dynamic interactions of its parts. For example, a system can exhibit an adaptive behaviour. This is an extremely important behaviour for a firm faced with intense competition and fast-changing customer demands. A key mechanism in adaptation is learning through a *feedback loop*. Some systems behaviour may be less desirable, as for example resistance to change. Here an organisation might refuse to adapt to changing market conditions and impose aging products and technologies onto its customers. As a system's behaviour is not easily predictable, operation managers use planning activities to guide and direct future behaviour. In system theory, planning is the application of a *feedforward loop*.

- *Hierarchy*: Systems are structured in hierarchies. A market is an economic system. A firm producing goods in this market is a subsystem of the economic system, and a system itself. The finance, marketing, and operations departments are three subsystems of the organisational system.
- *Boundary*: Systems have boundaries delimiting where a system ends and where the external environment starts.
- *Openness*: Open systems interact to a great extent with their environment. Open systems need to 'read' signals from their external environment and adapt in order to keep themselves aligned with external requirements.

### OPERATIONS SYSTEMS AS A TRANSFORMATION PROCESS

A widely used and popular way to model operations systems is as a transformation process as shown in Figure 2.1. In its most simple expression, it consists of stating that an operations system transforms inputs into outputs.

The transformation model of operations was initially developed for manufacturing operations. In this context, it is easy to see that the inputs are raw materials and purchased components, the process is a collection of machining or assembly sub-processes, and the output is a tangible good.

The model, however, does not require that the inputs nor the outputs be tangible goods. In the most general case, both inputs and outputs will be bundles of goods and services. Some examples of the transformation process in a non-manufacturing context are:

- A transport company which does not transform the goods it carries but alters their locations.
- A surf check website which uses a variety of information inputs such as wave charts, weather forecasts, offshore buoy readings, and surf cams to provide as an output a clear, easy to read surf forecast.
- In the case of personal services, such as hairdressers, where the input and output are identical but their state has been modified.

The transformation process is what organisation theorists call the *technical core*. The technical core is the source of competitive advantage for firms, and it is the assemblage of a set of specialist processes. The notion of the technical core is also very close to the notion of *core competencies* formulated by Hamel and Prahalad (1990), or to the notion of *strategic*

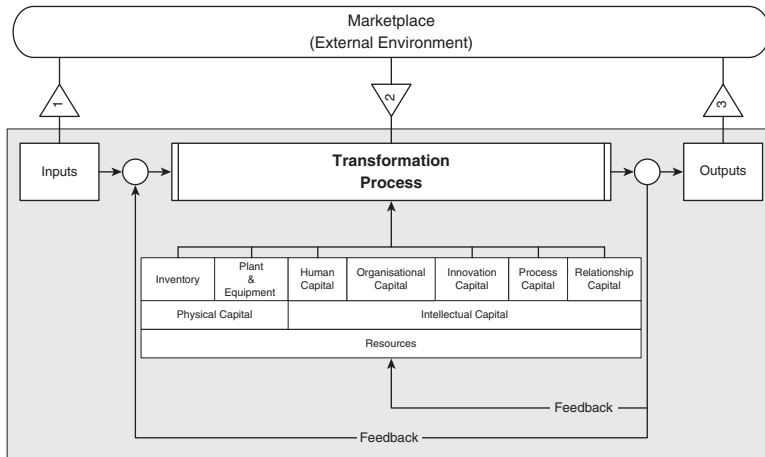


Figure 2.1 The transformation process model of operations systems

*competencies* developed by Hall (2000). Strategic competencies are characterised by the following properties:

- (i) They are responsible for delivering a significant benefit to customers.
- (ii) They are idiosyncratic to the firm.
- (iii) They take time to acquire.
- (iv) They are sustainable because they are difficult and time-consuming to imitate.
- (v) They comprise configuration of resources.
- (vi) They have a strong tacit content and are socially complex – they are the product of experiential learning. (Hall, 2000: 101)

## Resources

Developing and managing strategic competencies is only possible if managers can tap into a large pool of organisational resources. This is shown in the resource box below the transformation process in Figure 2.1.

The *resource-based view of the firm* is from the strategic management school of thought which brought the importance of resources to the fore in the 1980s. The definition of what constitutes a resource is very broad. For example, Barney (1991), one of the pioneers of resource-based theory, described resources as '*all assets capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by a firm*

that enable the firm to conceive and implement strategies that improve its efficiency and effectiveness'.

To some extent, this definition of resources is analogous to the accounting definition of an asset: a resource from which a firm can derive economic benefit in the future. The accounting definition highlights two fundamental properties of resources: (1) they require an investment and (2) there is some degree of uncertainty regarding the economic benefit which can be expected from them in the future.

Excellent business firms are those which invest in the development of resources that result in a competitive advantage. They take risky positions by investing in uncertain resources but receive high returns for the good management of these investments. The key challenge is to identify the required resources and to avoid under- or over-investing in them. In operations management, we are concerned with the following categories of resources: inventory, plant and equipment, and intellectual capital.

The job of an operations manager has traditionally been associated with the management of inventory and with the management of factories, or in the case of services, the management of the supporting facility. It was only in the 1990s, when managers started to exhibit maturity and excellence in their management of physical capital, that managerial attention turned to other resources such as intellectual capital.

In 1994, Skandia, a Swedish insurance company, was the first to point out that financial reporting was difficult when large differences existed between market value and book value (i.e. accounting value). In Sweden today, a ratio of 8:1 is common. In the United States, the market to book value ratio can be much higher. For example, Microsoft's market value in 1997 was 92 times its book value! This scale of difference is explained by the fact that most firms' resources are intangible. (this is especially true in the service sector).

In order to fully inform its shareholders, Skandia included in its annual report a supplement describing its 'hidden' resources: those could explain a firm's competitive edge and its high market valuation, but are not captured, or are only captured partially, by standard accounting methods. This set of hidden resources was labelled *intellectual capital*. Figure 2.2 presents the different components of intellectual capital.

- *Human capital* refers to the distributed knowledge and sets of skills of the individual employees of a company.
- *Structural capital* refers to how individuals have organised themselves and how well co-ordinated they are.

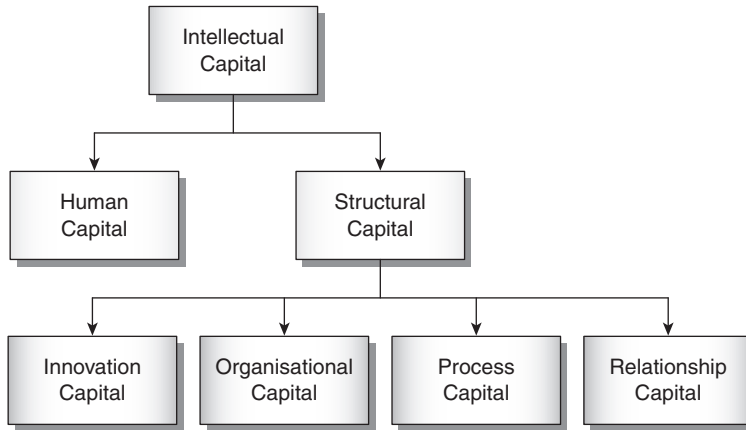


Figure 2.2 The components of intellectual capital

- *Organisational capital* refers to the organisational arrangements and structure which are in place and that form a framework for interaction and collaborative work.
- *Process capital* is of prime importance to operations managers. Process capital means possessing a full mastery of the inner working of the transformation process shown in Figure 2.1. It refers to whether or not all unnecessary delays, internal conflicts and non-value adding activities can be identified and eliminated. Operations management researchers have demonstrated through empirical research that proprietary processes and equipment are associated with higher levels of performance (Schroeder et al., 2002).
- *Innovation capital* refers to the extent to which the network of specialist processes within an operations system has been organised and structured in such a fashion that the system has high innovation capabilities. How often can new products be released? How expensive is it to bring a new generation of products onto the market? Are the core processes antiquated or state of the art?
- *Relationship capital* refers to how constructive the firm's relationships are with its suppliers and customers. Are these based on trust and collaboration and seek to maximise benefits for all parties, or do they suffer from adversarial practices which put a drain on profitability through penalties and legal settlements?

## THE ENVIRONMENT OF OPERATIONS SYSTEMS

The transformation process model of operation systems (Figure 2.1) is generic enough to be applied to any type of organisation, but it does not display the fact that different operations systems positioned in different markets are subject to very different types of demand characteristics.

Firms subject to different types of demand will structure and organise their operations systems differently and will rely on a different set of resources. Therefore, being able to understand similarities and differences in operations systems' contexts is extremely important. Key dimensions to consider when studying the environment of an operations system are:

- *Volume*: The extent to which demand for the product offered for the firm is small or important. Low volume systems are more flexible but also more expensive whereas high volume systems are rigid but produce products at a low cost due to economies of scale (see **Process**).
- *Variety*: This means the variety of products that a system has to process. High product variety means highly customised, one-of-a-type products whereas low product variety means highly standardised products with only minor 'cosmetic' variations. Products based on a standard platform which receives several possible types of finishing are in the middle of the spectrum (see **Platform**).
- *Stability*: Is the demand pattern stable or highly variable? Examples of unstable demand are seasonal forms (Christmas, summer, winter seasons), and demand laws which are highly dependent on economic cycles.
- *Variability*: Variability refers to the feasibility of changing design specifications, and it should not be confused with variety. For example, modern automotive producers are characterised by high-variety as they offer a great number of options on standard platforms. However, their system is also characterised by low-variability as customers do not have the option to order a product which is not listed in an official catalogue. Hairdressers, on the other hand, are low-variety systems (they only cut hair) but high-variability systems (what they deliver is unique for each customer). High-variability systems are often referred to as *engineered-to-order* systems. Low-variety and low-variability systems are *make to stock* systems, whereas high-variety, low-variability systems as *make to order* or *assemble to order* systems.



- *Service weight*: The extent to which the product delivered is a pure good, a pure service, or a mix of both.
- *Clock speed*: The extent to which competition forces frequent releases of new products. The computer industry is an example of an industry with a high clock speed as new generation processors are released very often. The restaurant industry is an example of an industry with a lower clock speed, as restaurant innovations are rare and tend to remain marginal.

### Systems control: the feedback loop

In Figure 2.1, feedback loops are the arrows going from the end of the transformation process to either the beginning of the process or to the resource box. A feedback loop indicates that an operations system is capable of self-adjustment. Feedback or system adjustment is triggered in control nodes where managers check that products conform to specifications (the trigger points are shown by circles in Figure 2.1).

For example, McDonald's pioneered the fast food industry by guaranteeing rapid service. If a restaurant manager notices that customers on average wait 20 minutes before being served, there is something wrong with the transformation process! It may be that staff at the counter and in the kitchen are too slow, in which case the restaurant is missing essential resources. Courses of actions may be to hire more staff, or to initiate more training to make sure that all staff are aware of McDonald's standards. Another reason may be that the manager never planned adequately for the volume of demand at a specific time of the day, for example lunchtimes. In this case the resources are available but insufficient. Opening additional service counters may solve this problem. Note that in this example we are adjusting resources. In other cases it will be the input of the process which will have to be adjusted. For example, a car may be defective because it has been fitted with defective tyres: in this case, the only adjustment which is required is to source better tyres.

### Systems boundaries

The upper half of Figure 2.1 displays three connections between the operations system and the external environment. These connections are represented by triangles symbolising either a transfer of control from the operations system to the environment (an upward triangle) or from the environment to the system (a downward triangle).

## System supply

*Vertically integrated* systems involve all the processes from the extraction of raw material to the manufacture of a final consumer good. Through experience with specialisation, firms have learnt that it is often impractical to cover an entire **supply chain**. For example, it would not be practical for an accountancy firm to manage a paper mill to make sure that it always had an ample supply of paper to hand! Instead, the accountancy firm will purchase paper from a specialist supplier. In doing so, the firm's performance becomes dependent on the performance of that supplier. The first upward triangle in Figure 2.1 symbolises this dependence, i.e. the fact that an operations system's performance depends on suppliers.

## Using outputs

Once products are sold or service provisions completed, customers will form a value judgment on them. Although a product or service may be designed with clear specifications, they might be perceived differently and used differently by customers. The second upward arrow in Figure 2.1 symbolises the transfer of control from the system to its customers.

For example, MacDonald's decision to use polystyrene packages to hold cooked burgers most probably originated with the desire to guarantee a high quality service and to avoid serving cold hamburgers to customers. When this decision was made, no-one within the operations system forecasted that some customers would react very negatively by pointing out that this form of packaging was not environmentally friendly. In other words, McDonald's destroyed value where it thought it would be creating it. This example illustrates the complexity of the transfer of control from operations system to customers as this transfer is about the formation of value judgments about outputs. This is discussed in more detail elsewhere (see **customer**).

## Specialist process, marketing risk, and social responsibility

The external environment – which comprises customers, regulators, and the public at large – also implicitly transfers a number of control rights to business organisations. This transfer is symbolised by the downward arrow in Figure 2.1. Examples of these interactions are:

- By switching to a new technology, an industry can indicate to a company that it is time to update its operating resources.
- Customers implicitly trusting that processes will be managed according to standard national expectations. For example, pollution levels should remain low and no child labour should be employed. When this implicit trust erodes, control mechanisms might be put in place (e.g. third party compulsory environmental audits). Governments typically assume that companies should conduct business according to regulations and should also pay all relevant taxes. Again, should trust erodes, further control mechanisms will be set up.

Whereas from the Industrial Revolution onwards the external environmental of operations systems has been one of lenient control, the reality of today's operations system is that more and more external regulations and controls are applied. Although these actions are usually implemented as the result of a real need, and while they usually seek the betterment of society, they usually make operations management more complex. The food and health industries are examples where operations management has to go hand in hand with strict statutory compliance.

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# Output

***An output is the conceptual description of the tangible or intangible end result of the act of producing through an operations system.***

## OUTPUT AND PRODUCTIVITY

Operations management is goal orientated: its purpose is to make sure that a **system** is used to produce an *output* from inputs. The production of outputs, however, is usually not without constraints. There may be several restrictions on inputs or resources used to generate the output. In the business world, a universal constraint is the cost of inputs and resources. This constraint is captured by the *productivity* ratio. Productivity is obtained by dividing outputs (e.g. in units or pounds) by inputs (e.g. in units or pounds, respectively). Operations management is about producing output with maximum, or challenging, productivity targets. In order to raise productivity, operations managers can:

- Find ways to produce more outputs with the same quantity of inputs.
- Maintain output levels but decrease inputs.
- Combine an increase in outputs with a reduction in inputs.

## FROM MANUFACTURING MANAGEMENT TO OPERATIONS MANAGEMENT

This output, or 'product', can take many forms but it is common to differentiate two types: goods and services. A *good* is a tangible manufactured output (i.e. something that can be touched) such as a computer, a book or a bicycle. A *service* is the provision of an intangible output (i.e. the provision of something which cannot be touched). Instead it may be felt, experienced, heard, smelt or appreciated. Examples of services include hairdressing, transport services (goods and persons) and dog training.

Historically, operations management emerged in the manufacturing sector. After the Industrial Revolution, factories used a variety of

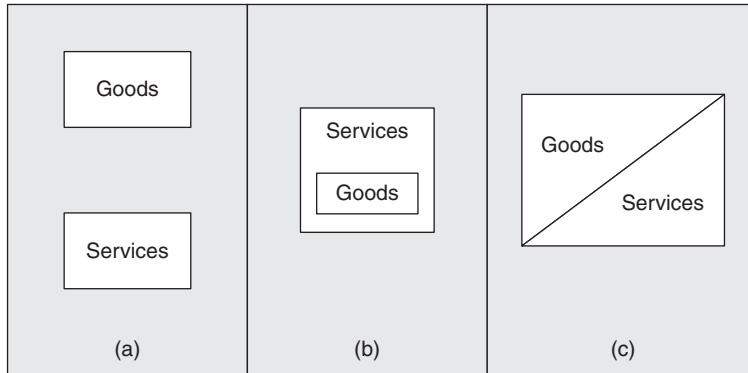


Figure 3.1 The three perspectives on goods and services

technological and managerial innovations to expand the scale of their operations. This scale became such that it was necessary to assign specialist managers to the task of managing operations. This specialty was named 'Production Management' or 'Manufacturing Management'. When these functions emerged, with their organisational departments, managers and staff, the service sector was, in comparison, small and marginal. For example, hotels were still small family-run businesses, rather than the 'giant' hotel chains of today which can often individually accommodate more than 2000 guests per night.

## GOODS AND SERVICES

In the last two decades, operations management as a formal academic discipline has slowly evolved to embrace the problem of managing operations for the provision of goods *and* services. Figure 3.1 describes the three perspectives which have been used in this shift from 'production management' to the broader concept of 'operations management'.

A first school of thought is to consider that goods and services are fundamentally different and thus that their provision processes are also so different that they cannot possibly be compared. This position is usually supported by stressing the key characteristics of services which are not possessed by goods, as illustrated in Table 3.1. This usually results in the belief that production management and service operations management are two different fields.

The strong distinction between goods and services suggested in panel (a) of Figure 3.1 is, at best, a moot point when one considers the following examples of intertwined goods and services:

- Some services, for example car repair, do not demand a customer presence. In that respect, running a repair shop is not very different from running a manufacturing job shop.
- Some business consultants specialise in providing off-the-shelf business solutions: the advice they sell is pre-typed, pre-thought and only needs to be customised to their client's specific context. In this case, intangibility does not affect the capacity to store the service offering.
- In the custom capital goods industry (e.g. assembly machines), customers and manufacturers interact a great deal during the design and manufacturing phases. In fact, it is common in this industry to send design engineers to work full time at the customer's site, and to invite a project manager from the buying company to work in a project team at the manufacturer's site. This exchange of workers helps to make sure that knowledge about how the capital good works is transferred effectively. Although labelled a 'manufacturing' transaction, this arrangement has a fundamental service dimension.

Given the variety of configurations within manufacturing and service operations, a clear-cut distinction between goods and services is only likely to be a gross generalisation. Table 3.1 is useful in simple cases, as for comparing car manufacturing with the provision of beauty services, but in the more complex cases, it would be more misleading than helpful.

A second school of thought (shown in panel (b) of Figure 3.1) is to observe that there are often similarities between the provision of services and goods, and that, more and more, these are provided simultaneously in a *bundle*. Take, for example, the case of *facilitating services*. These are services offered to customers which support the sale of a product, as for example a telephone support hotline linked to a computer purchase.

The distinction between services and products can actually become very difficult to make:

- Imagine purchasing a car with a full maintenance agreement (a facilitating service).

**Table 3.1 Goods versus Services**

	<b>Goods</b>	<b>Services</b>
Intangibility	Are highly tangible – quality can be assessed against objectives specifications.	Are highly intangible – assessment of quality is difficult before purchase. Assessment is perceptual and subjective.
Heterogeneity	Are highly standardised.	The service experience may vary.
Inseparability	Are produced in facilities which do not involve the customer.	Provision requires high levels of skilled customer-seller interactions.
Perishability	Goods can be stored.	Services cannot be stored.

- Or purchasing an operating lease, i.e. a service agreement through which you will lease (rent) the car, but all maintenance, repairs, taxation and insurance will be handled by the leasing organisation.

In these two examples what is provided is a product with a facilitating service or a service with a facilitating product. Practically, however, the product bundle that is offered to customers is almost identical.

Although this second point of view is a reality in several economic sectors, pure services and pure goods provision still exist today. This is why the perspective presented in panel (c) of Figure 3.1 is a more robust description of the different contexts in which operations managers have to work. Business organisations can provide a variety of product bundles, ranging from pure goods to pure services, with any possible mix in between.

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# Service Science

***Service science is the application of inter-disciplinary scientific methods to design and manage better service provision systems.***

## THE SERVICE REVOLUTION

As discussed in the previous concepts, operations management is a discipline that originated in the field of manufacturing management. Although some economies today still rely extensively on manufacturing sectors for their wealth, the service sectors in the vast majority of modern economies now dominate in terms of employment figures and contributions to Gross National Product (the service sectors of economies such as those of the UK or the USA typically employ more than 75 per cent of their national workforce). This phenomenon is referred to as the *service revolution*, and it sometimes requires acute adjustments at all levels within national economies. For example, old manufacturing management university degrees have to be replaced with service management degrees. This implies that researchers, lecturers, and textbooks must all adjust to new economic realities. Similarly, workers leaving a declining manufacturing sector in terms of employment opportunities have to reconvert their skill sets to new forms of employment. Even the legal aspects of businesses have to be rethought to match the new service-based economy (e.g. new e-commerce legislation).

In Occidental countries, the service revolution started in the late 1970s and service sectors have experienced constant growth since then. In terms of resource adjustments, the process is still continuing however, as changing resources such as skills sets, knowledge and best practice can be time consuming. As one might expect in a phase of economic transition, uncertainty and speculation are usually high and managing a business can often turn out to be a major challenge. Take for example Webvan, a major investment initiative by the US bookseller Borders in the sector of internet-based groceries retail. Webvan ended up as a major business failure along with many other 'dot.com' companies who were launched in an over-enthusiastic response to the 'internet service revolution'. Although the societal and economic changes that have



taken place since the Industrial Revolution and until today's service revolution have indeed been remarkable, it is important to remember that there are real economic forces at play, and that business and operations managers should take these into consideration.

### THE THREE SECTOR HYPOTHESIS AND BEYOND

The fact that the service sector would become more important than the manufacturing sector was foreseen by two economists (Colin Clark and Jean Fourastié) and is often called the *three sector hypothesis*. Simply stated, the three sector hypothesis stipulates that with time, employment and the economic contribution of the primary sector (agriculture and mining) will decline and shift to the secondary sector (manufacturing). Eventually, employment and economic weight will shift from the second to the third sector, i.e. the service sector.

It is worth highlighting the role that operations management plays in this economic transformation process. Take, for example, the transition from the secondary to the tertiary sector: at the beginning of the twentieth century, the manufacturing of a consumer good (e.g. a tool, a car) was a complex affair due to a lack of knowledge and technology. For example, the assembly of a car back then could take a couple of years, making this an extremely expensive good, and also making car assembly a viable operation only if a cheap workforce was available (as was the case in the nineteenth century where productivity improvements in agriculture meant that many unemployed agricultural workers were coming to the industrial urban areas in search of employment).

With operations management, this relatively inefficient form of production could be improved to the modern manufacturing standard that we know today. Note that the three sectors hypothesis does not say that the manufacturing sector will disappear (there are still many car factories in the UK, for example) and neither does it say that manufacturing will become an unprofitable activity. What it does say is that due to operations management knowledge, the productivity of these factories became such that only a handful of workers in a handful of factories are now needed to do the work that hundreds used to do. As a consequence, workers must exit the industry and seek employment in other sectors – typically sectors where productivity is still low and not mastered, or where labour is needed to offer new, or better, services.

There is considerable debate regarding what happens beyond the tertiary sector. Some suggest the existence of a fourth sector, the *information*

*economy*, dealing with the creation and diffusion of knowledge that therefore includes information management, education and research and development. Others advance the existence of a fifth sector, described by some as the government (health, police, etc.) and the not-for-profit sector. Yet others put forward a fifth sector, the *experience economy* (experience is defined by the quality of emotions and feelings experienced by customers). Clearly, although it is evident that these three additional sectors are indeed growing quickly, it is not certain as yet which of these will grow faster than the others. What is known, however, is that in each of these sectors there should be important efforts to apply operations management as a discipline in order to improve productivity and generate wealth.

### SERVITISATION

The service revolution is also having an impact on the manufacturing sector. Similar to the quality revolution which took place in the 1980s when companies had to adopt quality as a competitive weapon, modern manufacturing firms cannot survive without embedding services within their products. The trend is known as *servitisation*: the idea that manufacturing firms should be managed as service providers rather than as producers, as value to customers lies in the overall service provision and not just in the acquisition of a product.

### SERVICE SCIENCE

*Service science* is the ongoing response to a desire to improve productivity in the service sector. Initially an approach developed by IBM, service science, or 'service science, management and engineering' (SSME), is an interdisciplinary approach attempting to bring to services the rigour that work study and operations management brought to work methods in manufacturing. Due to the specific intangible, emotional and perishable aspects of services, service science requires the integration of theories from management science, the social sciences and the engineering sciences. The emergence and popularity of call centres is a typical example of the outcomes of service science: call centres and the provision of telephone banking services are good examples of the application of the standard operations management principles – standardisation of tasks and processes, standardisation of scripts to guide customer contact, establishment of standards time to achieve performance targets, etc. Hefley

and Murphy (2008) provide an extensive review of this emergence and of the best practices in service science.

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# Customers

***Customers are the ultimate recipients of the provision of a good or service by an operations system. They can be close to, or remote from, an operations system, but in all cases their demands and needs are the prime inputs for the design of an operations system.***

### CUSTOMERS AND RELATIONSHIP CAPITAL

As an operations manager, in what ways should you think of customers? Customers form judgments about the value of the output of operations systems and in doing so they exert a direct or indirect pressure on an operations system. Customers could be seen as troublesome, as it is from them that complaints, excessive demands or pressures to operate in different ways will stem. Alternatively, customers and their needs are the only reason why an operations system exists in the first place. If customers only expressed a need for luxury travel, low cost airlines would disappear. If customers desire cheap travel, low cost airlines will thrive.

In a free market economy, it is essential that an operations system's output matches customer expectations. This is why many of the operations management frameworks described in this book (e.g. TQM and

**Six-sigma**) will take customer satisfaction as the starting point for any corporate improvement initiative. The central importance of customer satisfaction in operations management is explained by the fact that a positive relationship between a firm and its customers is a resource (relation capital, see **System**) by which the system performance can be increased. Berry and Parasuraman (1997) use factor analysis to classify the various behavioural intentions of customers as follows:

- *Customer loyalty to the company*: for example, a loyal customer may encourage friends to do business with a company. Loyal customers are happy to commit to more business with this company. Non-loyal customers will do the opposite.
- *Propensity to switch*: customers may be reluctant to switch (a source of capital) or may always be switching (for example, for better one-off deals).
- *Willingness to pay more*: this can be observed for example when products are priced higher than those of the competition whilst remaining bestsellers.
- *External response to a problem*: should a problem occur during a transaction, would the customer complain to a regulator, engage in legal action, or divert their business to a competitor?
- *Internal response to a problem*: the customer will attempt to solve problems by contacting the company's employees.

It may come as a surprise that operations management will directly concern itself with customer needs as these are by definition the specialist area of marketing. The distinction between operations management and marketing as business functions is an example of the principle of division of labour at work. Specialisation, however, requires co-ordination. This means that when operations managers concern themselves with customers, they are not trying to compete with their marketing departments. Instead, they are making sure that the interface between marketing and operations management is working effectively. There are three ways in which operations managers can, along with marketers, participate in managing the relationship with customers:

- 1 *Listening to customers* involves a number of tools and techniques used to translate external performance specifications into internal specifications (see **Performance** for more information on performance management).

- 2 Many service provisions require the involvement of contact personnel. *Customer contact* refers to a set of specifications and guidelines for the effective co-production of services.
- 3 *Personalisation* in operations management is a set of capabilities used to provide a customised service to large customer segments.

## LISTENING TO CUSTOMERS

Listening to customers can be a challenge in operations management for a variety of reasons: they may not be in contact with the system (e.g. manufacturing), or there may be contact but there is variability between the needs of customers (e.g. in a doctor's practice), or customers may not know exactly what they want (e.g. a consultant facilitating a strategy analysis meeting for a corporate client).

Throughout the concepts in this book, you will find references to customers and customer satisfaction, a reminder that organisations will often have multiple goals. A business firm, for example, will seek profitability and customer satisfaction. A government agency will seek public utility and stakeholders' satisfaction.

Berry and Parasuraman (1997) go further and argue that listening to customers should be made a more formal and structured activity by introducing the concept of a *service quality information system*. They therefore provide an exhaustive list of the mechanisms through which organisations can listen to their customers (surveys, focus groups, mystery shopping, service reviews, etc.) and they also summarise the goals of an effective service quality information system:

- Take into account the voice of the customers when making decisions.
- Reveal customer's priorities.
- Identify improvement priorities and guide resource allocation.
- Track company performance along with that of competitors.
- Disclose the impact of service quality initiatives and investments.
- Provide a database to be used to correct poor service and to recognise and reward excellent service.

*Customer Relationship Management* (CRM) systems are computer-based systems that allow large firms to build a database and to interact with customers, as for example through the management of loyalty card schemes. CRM systems attempt to maintain a feeling of personal care and

a relationship when the volume of customers is such that maintaining personal contact would not be feasible.

In the rest of this section, we discuss two techniques used in operations management to listen to customers at the stage of designing products and services: customer-perceived value and quality function deployment.

### Customer-perceived value

Miller and Swaddling (2002: 88) define customer-perceived value (CPV) as ‘the result of the customer’s evaluation of all the benefits and costs of an offering as compared to that customer’s perceived alternatives. It’s the basis on which customers decide to buy things’.

Miller and Swaddling argue that customers go through a cost-benefit analysis when they decide to acquire a product. Benefits include the financial impact of purchasing the product (e.g. increased revenues or reduced costs), time savings, increased safety, and prestige derived from ownership. Costs include the purchase price, the training required for the user, the process changes required from the adoption of the product, and tax and insurance considerations. Customers will only acquire a product if perceived benefits exceed perceived costs.

Miller and Swaddling further posit that:

- *Customer value is market-perceived:* This means that like beauty value lies in the eyes of the beholder! A product which is technologically superior will not necessarily be a bestseller. This is why companies should focus on understanding how customers make value judgments in the marketplace.
- *Customer value is complicated:* There may be many variables at play in a customer’s mind when making a decision.
- *Customer value is relative:* Value is assessed relative to the alternatives the customer perceives they have. Companies should endeavour to discover what these alternatives are.
- *Customer value is dynamic:* Customers’ perceptions of value are permanently evolving with their changing circumstances or with changes in the marketplace.

The recommendation in Miller and Swaddling’s work is that significant research resources should be devoted to **New Product Development (NPD)** and **New Service Development (NSD)** to understand

customer-perceived value. Researching customer-perceived value can be achieved through using tools and techniques which will focus on customers, such as lead users methodology and ethnographic design (an approach where the design is preceded by studying the 'persona' of customers). Other techniques include one-to-one interviewing, focus groups, customer advisory panels, customer role playing, and the organisation of customer events.

### Quality function deployment

*Quality Function Deployment*, or *QFD* (Akao et al., 2004), is a technique that was developed in Japan in the late 1960s in order to make sure that design activities would balance the engineering perspective with the 'voice of the customer'. The driving idea behind QFD is to take into account customer needs before a product is designed and built, not afterwards. QFD can be used in any design activity: new product development, technology selection, service development, and process design.

One of the strength of the QFD methodology is its ability to co-ordinate decisions amongst different departments over time while maintaining the integrity of the initial customer specifications. For example, a QFD exercise included in the concept design can feed into another QFD exercise at the detailed design stage, which could in turn feed a process design QFD exercise. Thus, QFD is one way of achieving **cross-functional integration** and **co-ordination**.

### CUSTOMER CONTACT

Customer contact is the extent to which the customer will be part of the execution of a process. In manufacturing settings, operations managers are rarely in direct contact with customers. To deal with the complexity of dealing with an end customer, specialists in sales and marketing will intervene. This practice has been described by organisational theorists as 'buffering the technical core' (Thomson, 1967). Buffering this technical core, i.e. trying to isolate the core of the firm from the end customer, is also called *decoupling*. By introducing an interface between the customer and the technical core staff, each party deals with a simplified problem. For example, a factory is protected from demand fluctuations by an inventory buffer. Similarly, process engineers are protected from a direct interaction with end customers by the sales department. In manufacturing operations, decoupling is systematic.

Chase (1981) suggested that decoupling has been almost a systematic practice in manufacturing because customer contact has a negative impact on efficiency:

$$\text{Potential facility efficiency} = \frac{f(1 - \text{Customer Contact Time})}{\text{Service Creation Time}}$$

According to Chase's formula, activities which involve customer contact time are inherently slowed and maximum efficiency can only be achieved if contact time is eliminated.

In the service industry, however, customer contact is the norm. Babbar and Koufteros (2008) highlight that, initially, customer contact in operations management simply meant the presence of a customer in the operations system. It was then recognised that an operations manager should pay attention to the actual interaction which takes place between the service provider and the customer. This interaction is often called the *service encounter*. In the most complex cases, the customer is actually involved in the definition, design and delivery of the service along with the contact personnel: this is referred to as *co-production*. A side issue in the days when manufacturing dominated the economic scene, customer contact has increasingly been recognised as a fundamental research issue in operations management. This has resulted in the formulation of 'contact theory', that Babbar and Koufteros (2007: 818) define as recognising 'the interface between the firm and customer to be a seminal element of consideration for service firms and contact employees as providing service-delivering firms valuable opportunities for responding to the needs of customers, satisfying them, and helping to build a relationship with them'.

The legitimacy of contact theory was established by Soteriou and Chase (1998), who were the first researchers to demonstrate empirically the existence of a relationship between customer contact and perceptions of service quality. Moreover, providing excellent customer contact can also have other impacts on performance besides service quality. High levels of customer contact can supply opportunities for marketing the firm and its other services (Chase et al., 2008) or for building trust and confidence between the firm and its customers. For example, although the computer manufacturer Dell was once famous for its outstanding level of customer service, it went through a phase of decline which culminated with negative sentiments toward Dell being held by 48 per cent of its customers. When Michael Dell returned to the company in



2007, one of his first campaigns was to re-establish customer contact. Dell employs a team of 42 employees who spend their days interacting with customers on social networking web sites such as Facebook in order to feed the information that they collect back to the company's designers. As a result, negative sentiment toward Dell dropped to 23 per cent in 2008 (Forrt, 2008).

### Customer contact and design of service system

High contact service systems and low contact service systems are very different in terms of system requirements. In addition to being able to distinguish between the design requirements of high and low contact systems, operations managers should also understand what it is in their respective industry that creates a good contact experience. For example, Babbar and Koufeteros's (2008) research shows that the perception of airline service quality in the USA was based on customer contact as measured by personal touch. Personal touch was defined as individual attention, helpfulness, courtesy and promptness.

### When should we decouple operations?

A key systems design issue is deciding at what point a process must become decoupled from this interaction with customers. Different service sectors will require different (or will not lend themselves to) ways of decoupling.

According to Chase (1981), services can be categorised as:

- *Pure service*: where contact time is unavoidable (e.g. medical services, restaurants).
- *Mixed services*: where decoupling takes place. The customer-end of the service is called a *front office*; the part of the service which is decoupled is called a *back office*.
- *Quasi-manufacturing*: there is no customer contact, e.g. a distribution centre.

Chase suggests the following procedures for analysing which contact strategy should be followed for a service:

- 1 Identify those points in the service system where decoupling is possible and desirable.
- 2 Employ contact reduction strategies where appropriate.

- 3 Employ a contact enhancement strategy where appropriate.
- 4 Employ traditional efficiency improvement techniques to improve low contact operations.

## PERSONALISATION

### From mass production to mass customisation

The Industrial Revolution and the societal changes that came with it were made possible due to the development of new technologies and the exploitation of economies of scale. Mass production, however, has a drawback. Through its focus on reducing costs and intensifying the pace of production, it does not allow for the customisation of products. Henry Ford, for example, was famous for his statement that a Model T could be ordered in any colour, provided that this colour was black! There is a simple production explanation for this policy: back in the 1910s, the technology did not permit a rapid change of colour in the painting shops. Switching colours in a painting room might have required several hours for cleaning equipment. These hours represented precious time lost that would lead to a decrease in productivity and profitability.

Henry Ford's first competitive challenge came in the 1920s from General Motors: recognising the need for more diverse products in the market, General Motors built four separate factories producing four different models, each available in different colours and versions. In terms of costs, these factories could not compete with Ford: the scale and variety of products on offer were such that their cars were much more expensive. However, a demand existed for differentiated cars and General Motors thrived in this business, eventually forcing Ford to abandon production of the Model T and to release a new product, the Model A.

At a small scale, the competitive battle between Ford and General Motors in the 1920s was the ancestral version of the rise of *mass customisation* in the 1980s. Competing via cost is only a powerful competitive strategy if customers value cost and no other performance dimension (see **Performance**). After World War II, most industrial developments took place in a climate of economic reconstruction and therefore customers could not afford to be too specific in their demands. Ordering a customised product was always possible, but it came at a premium price and with a very long lead time. However, the nature of demand gradually evolved toward more and more differentiation of

needs. When marketers used to specify products on the basis of the average of a distribution, they started to look at the shape and range of the distribution. They recognised that different segments existed under a demand distribution, and throughout the years that followed, the notion that firms may be able to serve a 'segment of one' started to gain ground. The resulting idea, which was documented in the early 1980s, was called mass customisation. Hart (1995: 36) defines it as: 'the use of flexible processes and organisational structures to produce varied and often individually customised products and services at the low cost of a standardised, mass-production system'.

### Mass customisation strategies

Gilmore and Pine (1997) have identified four approaches to implementing a mass customisation strategy:

- *Collaborative mass customisation*: The customer is directly involved with the co-specification of the product, and potentially in its co-production.
- *Adaptive customisation*: This corresponds to a slightly different need, as the customer can adapt the product or service to match his or her changing needs. In other words, the provider recognises that customer needs fluctuate (with weather, mood, etc.) and builds into the product the possibility of adapting it to circumstances.
- *Cosmetic customisation*: This strategy focus on the appearance or packaging of the product, which is usually the last stage in production. The customer will select an appealing product from a very wide range of combinations, or can buy different panels or 'fascias' to customise their products later on during consumption.
- *Transparent customisation*: In this approach, the customer cannot or does not have the time or knowledge to specify the exact nature of their needs. As a result, the supplier takes control and provides a customised product or service without the customer being aware of this fact.

### Mass customisation: the process side

The key challenge of mass customisation is not to personalise the provision of products or services, but is to do so whilst keeping costs at similar level than is the case for mass production. There are number of capabilities

and process innovations that can be implemented to support a mass customisation initiative, from the operations side. It goes without saying that marketing should also be involved in the process, as this will play a key role in eliciting, capturing, and documenting customer preferences. Key operations capabilities supporting mass customisation are:

- *The use of modules in product designs*: This means that customising the product becomes a simple matter of assembling it from different modules, rather than redesigning the product every time. (Platform technology and the use of modules are described in more detail in **Platform**).
- *The use of flexible processes*: This allows a single facility to handle 'batch sizes of one', and therefore to achieve a smoothed production of mass customised products (see **Flexibility**).
- *Responsiveness*: This is a requisite and especially important in the apparel industry, where point of sales data systems can capture in real time the fact that a specific product version is proving successful. Through quick response supply chains, production of this version can be scaled up so that more adequate quantities can be supplied to the stores (see **Responsiveness**).
- *Postponement*: This is another key capability in mass customisation (Feitzinger and Lee, 1997). A product can be decomposed into a common core and customisable elements. The idea of postponement is to delay the provision of customisable elements until the latest possible stages of production, in order to allow upstream production stages to experience economies of scale.
- *Use of technology*: Thanks to information technology, it may be possible to offer customised services at a minor cost. Airlines and some ferry companies, for example, have uploaded diagrams of their seating arrangements on the internet to allow customers to choose their seats if they desire to do so.

## MASS CUSTOMISATION OF SERVICES

Mass customisation in the service industry is a puzzling affair. Historically, the service sector has been famous for naturally high levels of service personalisation, an important competitive capability derived primarily from the quality of contact personnel. Take the example of personal banking services up until the mid 1980s. The typical organisational design of a retail bank was that each customer would be allocated

a personal advisor, who could be contacted when customisation was needed. Non-customised services were delivered over the counter.

Instead of going through a mass customisation revolution, the retail banking industry went through a mass production revolution. Many of the banking innovations of the 1990s and early 2000s had to do with cost cutting and productivity enhancement: the use of call centres and telephone banking, the retirement of personal advisors, etc. When the need for a customised service appears today customers will still be offered a personal consultation, but with an employee who will have no previous contact or history with that customer. As a result, most of the relational advantages that existed in the old configuration have disappeared.

In a survey of the UK financial sector, Papathanassiou (2004) showed that a majority of respondents saw a strong potential in mass customisation as a potential to improve the personalisation of services and recognised the internet as the most promising medium to do so. For example, Amazon's personal recommendation service, which is based on the data mining of a very large transaction database, shows how by using technology a firm can maintain on a large scale the 'feel' of a relation. Similarly, Yahoo! Launch radio is an internet-based personal radio channel that plays music based on the rankings previously entered by each user.

The idea that the internet-based or technology-based mass customisation of services has a bright future is beyond debate. It is indeed a promising avenue for competitive improvement. A question remains, though, regarding the service industry's past practice of dismissing human-based mass customisation. Note that when the manufacturing sector adopted mass customisation, the specification was to increase customisation while maintaining cost performance. The service sector could, in comparison, be accused of having increased cost performance while reducing customisation.

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## Technology

***Technology is the application of scientific knowledge to the change and manipulation of the human environment.***

### DEFINING TECHNOLOGY

The term technology is a combination of the Greek *techn* ('art', or 'craft') with *logos* ('word', 'speech') meaning a discourse on the arts, both fine and applied. In other words, it means the application of scientific knowledge to the change and manipulation of the human environment.<sup>1</sup> Technology, therefore, refers to the know-how – techniques – which are combined into a process to be executed. The term includes hardware

<sup>1</sup>The author is indebted to Professor David Bennett, Professor of Technology Management at Aston Business School, for this definition.

technologies (e.g. computers, the internet), software technologies (e.g. a web browser), and 'human-ware', (for example the tacit knowledge of the execution of a process (e.g. the skills displayed by a top chef).

## TECHNOLOGY IN MODERN OPERATIONS MANAGEMENT

The association of technology with operations management is a fundamental tenet of the 'age of enlightenment', where the betterment of life and of consumers' experiences is continuously sought. One fundamental aspect of progress in 'modern' operations management is the law of technology, which stipulates that efficiency can be derived from the adoption of technologies performing specialised tasks. Although many concepts in this book make reference to the principles of the division of labour as one of the foundations of operations management, it is important to realise that technology has played an equally important role in the shaping of modern operations systems. As captured by the definition given above, technology is not only used to refer to plant and equipment but also to other resources such as process capital (ways of doing things), innovation capital (the ability to integrate new technologies into existing product platforms), and organisational capital (new ways of organising).

Technology has been such a prevalent factor in changing the practice of operations management since the Industrial Revolution that it is impossible in one short paragraph to provide an exhaustive list of all the underpinning 'revolutionary' technologies. Examples include the steam engine, transport technologies, just-in-time production methods, standards of tolerance for mechanical parts, and intelligent manufacturing. Along with many others, these technological innovations have shaped what manufacturing and service companies can and do achieve.

How technology shapes operations systems and entire business firms is a long-established research stream in organisational theory. Amongst the key pioneers was Woodward (1958), who showed that depending on the degree of technical complexity in the workplace certain patterns of structure and work practices were most suitable. Woodward's work is famous for her classification of 100 British manufacturing firms based on patterns of structure and technology.

Thompson (1967) is another pioneer of the so-called technological determinism school: instead of looking at technical complexity, he studied patterns of interdependence implied by technology at work. His work is highly relevant to operations management as each type of interdependence pattern corresponds to specific operations management

approaches in terms of designing and planning work processes. Thompson's work is also frequently cited in **supply chain** management research. The third contributor of technological determinism here is Perrow (1970) who classified various technologies into four categories as a function of task variety and predictability at work. Again, the contribution is to explain viable patterns between work context, technologies, and structure.

## TECHNOLOGY-INDUCED BUSINESS TRANSFORMATION

It is important to appreciate just *how* technology affects operations. A good example is provided by Venkatraman's (1994) study of the impact of information technology on business practice. Through a review of the investments in IT of major US corporations, Venkatraman identified five ways in which IT can transform business operations:

- *Localised exploitation*: These investments are isolated systems solving specific productivity problems. Inventory management systems, for example, are used to automate a task but do not imply a redefinition of work processes.
- *Internal integration*: These investments have two purposes. The first is to guarantee technical interconnectivity, so all users in a firm can access the same technological platform. The second is to integrate business processes so that roles and responsibilities are clear and understood by all (see **Integration**). Duplicate or conflicting roles, for example, have to be eliminated before any corporate-level improvement can be applied.
- *Business process redesign*: Following the technological determinism school, Venkatraman argues that most business processes were developed because of technological and environmental constraints. When IT technologies are introduced at work, process analysts can free themselves from legacy constraints and find new, more efficient, ways of working. In this case, IT adoption leads to the redefinition of operations systems.
- *Business network redesign*: The previous idea can be applied beyond the boundaries of an organisation to the business network that it belongs to. Through appropriate information systems and IT platforms, distribution specialists can redesign distribution channels. Direct sales channels from manufacturers to customers or from



wholesaler to customers (e.g. Amazon.com) are examples of business network redesign.

- *Business scope redefinition*: At the highest level, IT technology developed in-house may be deployed to enter completely new markets. Airline reservation systems and e-business models are examples of IT technologies that first movers have been able to sell to other commercial sectors.

The impact of technology on operations is so important that most large corporations will employ specialists – technology managers – to help them identify which technologies they should invest in (see **Technology management**).

## TECHNOLOGY, SOCIETY, AND FUTURES

The pioneering school of technological determinism laid the foundations for the investigation of *how* technology affects society and how society affects technologies. Operations managers usually concern themselves with technology management, but it is important to appreciate that there is an ongoing and healthy debate surrounding the concept of technology beyond its use in operations systems. Webster (1992) and Johnson and Wetmore (2008) are examples of authors who are exploring the wider question of society and technology.

In particular, the school of *socio-technical systems* argues that there must be a fit between social arrangements and technical systems. Socio-technical system theory has implications when designing work and processes.

## TECHNOLOGIES AFFECTING THE FUTURE OF OPERATIONS MANAGEMENT

To conclude this concept, it is relevant to highlight that one of the responsibilities of an operations manager is to keep abreast of technological developments in order to identify which technologies, will transform operation systems in their particular industry. Examples of current key transforming technologies include:

- Bio-engineering where new products are designed by combining principles from mechanical engineering and biology.
- Nanotechnology for the design and manufacture of very small (the scale of a few microns) mechatronic products.

- E-commerce technologies that have resulted in a new field of study, e-operations, within the discipline of operations management. These have an especially strong impact on service operations management, such as the provision of online banking services.
- Space commerce which was once the restricted domain of highly-funded government agencies, but more and more corporations are entering the arena. The company Virgin Galactic even offers (wealthy) customers trips in a space shuttle. At the time of writing this book, there is no specialist 'space operations management' publicly-available body of knowledge, but as space commerce grows it is clear that this body of knowledge will emerge.

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## Co-ordination

***Co-ordination is the alignment and synchronisation of people, processes, and information within operations systems in order to maximise productivity.***

### CO-ORDINATION

One of the consequences of seeking performance through specialisation is the need for co-ordination. The ability to co-ordinate, thus, is a core activity of operations management. Simply put, the challenge of operations managers

is to make sure that all resources, inputs, and processes are available in the right quantity, in the right place, at the right time, in order for productive activities to take place.

Mintzberg (1983) was one of the first academics to write about co-ordination. He listed the following ways through which work could be co-ordinated:

- *Mutual adjustment*: Co-ordination is achieved by informal communication between the people doing the task, as for example when two canoeists paddle along a river. Although operations management co-ordination tends to use more formal mechanisms, certain cultures favour this type of co-ordination. Japanese work production teams, and the self-managed teams recommended by the socio-technical systems approach (popular in Scandinavian work systems, see **Work**), are examples of co-ordination through mutual adjustments. Research on behavioural operations management deals with this type of co-ordination.
- *Direct supervision*: Direct supervision is more of a management issue than an operations management issue. How a person is made responsible for the work of another, and how a person manages this relation, are the prime responsibility of a line manager.
- *Standardisation of work processes*: This has been the main battlefield for operations management, especially through the scientific management movement. Its modern descendant is the field of process management (see **Process Management Section**).
- *Standardisation of outputs*: This is done through the planning function, where levels of outputs (quantities, costs, quality levels) are set, and resources are allocated accordingly. Co-ordination through planning is discussed in **Planning and Control**.
- *Standardisation by skills and knowledge*: When workers are given specific roles that use their specific (and standardised) skills, co-ordination is automatically achieved. Examples are legal offices and academic departments, where each individual knows his or her respective role and acts only in ways prescribed by a professional code of conduct.

## CO-ORDINATION THEORY

Many business and non-business disciplines concern themselves with co-ordination. This is not surprising as the reality of modern organisations,

(see **Operations**) is one of high interdependence within large, potentially dispersed, networks of specialists. Malone and Crowston (1990) observed that although there is a lot of research done about co-ordination in different fields, there is little if any effort to integrate the different research streams together. Through a multi-disciplinary review of the literature, they propose a theory of co-ordination, which they define as the *body of principles about how activities can be co-ordinated, that is, about how actors can work together harmoniously*.

Their theory first identifies the components of co-ordination, which are: *goals, activities, actors, and interdependencies*. The purpose of co-ordination theory is to manage interdependencies so that actors can complete the required activities in such a way that goals are attained. Should goals be changed, activities, actors and interdependencies may have to be adjusted. This is the case for any of the four components.

Malone and Crowston (1990) then investigated the different types of interdependencies, and found themselves following the path of the technological determinism school (see **Technology**). They do not provide a full taxonomy of interdependencies and instead give a preliminary list of different kinds of interdependence. These examples include:

- Prerequisite: The output of an activity is required by a downstream activity.
- Shared resources: Different activities utilise the same resource.
- Simultaneity: Two or more activities should be completed at the same time.
- Manufacturability: what the design department produces should be manufacturable, i.e. process engineers should be able to design a manufacturing process.
- Customer relations: Two or more actors deal with the same customers, for example a salesperson and a field technician.

Finally, Malone and Crowston (1990) listed the processes underlying co-ordination. The first category grouped pure co-ordination processes. These can be applied to the four components of co-ordination. Pure co-ordination processes include identifying goals, ordering activities, assigning activities to actors (scheduling), allocating resources, and synchronising activities. All of these are typical operations management processes and are discussed in more detail throughout this book.

Group decision making is a second class of co-ordination processes and is about making collective decisions. This includes proposing alternatives, evaluating alternatives, and making choices.

Communication is another class of co-ordination processes and is about establishing common languages, routing information flows, and diffusing information within an organisation.

Finally, the last class of co-ordination processes is about the perception of common objects. It is important that actors see objects (products, customers, plans, etc.) in the same way so that any decisions made are not based on different interpretations of the facts. This is where standards, training, or the use of shared databases come into play.

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# Planning and Control

***Planning is the organisational process which is used to set, discuss, validate, adopt and revise goals and objectives.***  
***Control is a feedback process through which operations managers adjust their plans, actions and knowledge***

## PLANNING AND CONTROL AT WORK

Figure 8.1 illustrates planning and control in action. It shows that planning is a *feedforward* process (the downward arrows in Figure 8.1), whereby operations managers attempt to anticipate the future, design adequately co-ordinated operations systems, and efficiently utilise these systems.

Organisations attain their goals through *controlled performance*: this means that organisations use control processes to verify that plans are being followed or that adequate actions are being taken in the opposite case. Control is a *feedback* process (indicated by the upward looping arrows in Figure 8.1). Although control sometimes carries a negative

connotation – as for example when thinking of control as surveillance or control as a lack of trust – it is important to note that in operations management, as in systems theory, control is a positive mechanism: it is a way to highlight issues, to trigger analysis, to learn, and to stimulate the improvement of operations systems. It shows that the desire to anticipate future needs and demands is what drives organisations to plan. At a corporate level, understanding future demand has two dimensions:

- Future demand should be estimated qualitatively, that is in terms of the future specifications of the product and services which will be demanded. This is one of the responsibilities of the marketing function.
- Understanding future demand quantitatively is a general corporate concern which is addressed through forecasting (see **Forecasting**).

Given an estimate of future demand, operations managers then apply their know-how of the business to set goals for their operations systems and select the resources that they will need to attain these goals. When the plan focuses on the timing of actions to implement, this is referred to as a schedule. When the plan incorporates cost elements, this refers to a budget.

A plan is basically a structured presentation of how a goal will be attained. Who will do what, and when? What technologies will be used? How will production be gradually increased? Will learning curve effects lead to automatic increases in productivity? These are only a few examples of the numerous questions which have to be answered in planning.

Once a plan is completed, it is communicated to all interested parties so that during the execution everyone in an organisation will know when action is needed and how different actions fit together.

There are two mechanisms by which the difficulty of producing realistic plans can be addressed. First, planning is usually a group rather than an individual process: because of the breadth of knowledge required, it is necessary to tap into the expertise of several specialists rather than one individual. Second, planning is an iterative process: in (common) cases where planning is very complex, a first plan is produced and executed. A first plan, designed using a blank piece of paper, is generally unlikely to be very good. By monitoring its execution, operations managers can discover where the plan is going wrong, understand why this is so, and decide what they should do about it.

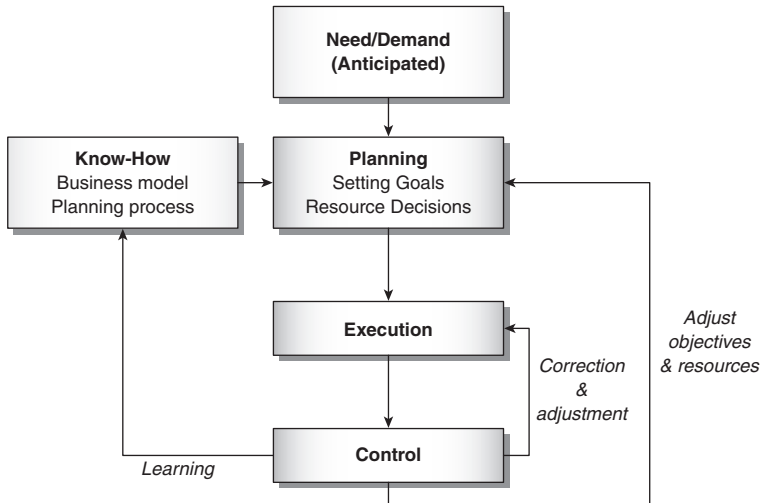


Figure 8.1 Planning and control in an organisation

It is through effective control systems that operations managers can:

- Detect that the plan is not being followed and take immediate corrective action.
- Appreciate that the goals are unrealistic or the resources inadequate; again corrective actions can be implemented.
- Learn that the planning data (or assumptions) were erroneous and need to be improved.

### MATCHING DEMAND WITH SUPPLY

Planning and control are not the sole responsibility of operations managers. Within organisations, all business functions play a role in the planning and control cycle depicted in Figure 8.1. Accountants, human resource managers, and marketers all have to plan and control both within their departments and across their organisation. Each business function, however, focuses its planning and control processes on its specialist area. For example, accounting and finance departments focus on planning and controlling for funds and profitability.

*The operations function's prime planning and control concern is to make sure that the organisation can match demand with supply. As operations*

managers are ultimately responsible for the design and operation of a firm's resources, they are also responsible for making sure that these resources deliver products and services of the right specifications, to the right customer, at the right time.

## PLANNING HORIZONS

A common distinction, made in all planning disciplines, is to differentiate the nature of planning and control activities on the basis of planning horizons (Anthony, 1965).

*Long-term planning* is concerned with the distant future. In general, long-term planning means planning for the next two to ten years. What constitutes the 'long term' is a function of the operating cycle of an industry. For example, in the car industry new models are released every three years, whereas major platform redesigns occur about every five to seven years. In the forestry industry, exploitation cycles can be very long: in Northern Europe the growth cycle of pine trees is about twenty years, whereas hardwood species need one hundred years between plantation and harvest. Thus, forestry planning tends to be based on much longer time horizons than most industrial sectors.

Long-term planning is also often called *strategic planning*, as it focuses on declining the strategy and long-term goals of the organisation into quantitative plans. At this level, demand is estimated as an aggregate. A computer manufacturer will estimate the number of computers to be sold (without detailing the exact models or version which will be sold), or it may set target sales for key models (but still exclude some versions). Similarly a consulting firm will estimate its total hours to be sold, without decomposing the hours in key types of consulting products. In operations management, strategic planning is achieved through **operations strategy**, system design and resource decisions.

*Medium-term planning*, or *tactical planning*, is concerned with planning for the next six to 24 months. Key resources are now fixed: it is impossible, for example, to double the capacity of a factory in six months. Strategic planning (the past decision made about capacity) *constrains* medium-term planning. It is within the perimeters of existing resources that managers must match expected demand. The strategic stage sets an average capacity level in units per month. Based on market observations, economic conditions and between months variations (seasonality), managers now have to come up with *tactics* to match demand. In accounting, medium-term planning is often called *management control* to highlight



that it is a phase where managers adjust objectives and resources, or correct the execution, on the basis of evolving market conditions. In operations management, medium-term planning is called *aggregate production planning* (APP).

Finally, *short-term planning* deals with planning and control activities for the next six to 12 months. The output of short-term planning is a schedule which is often broken down into very detailed specifications of future activities per month, per week, per day, and eventually per hour. At this level, plans are prepared on the basis of completely disaggregated data. Plans are still constrained by the decisions which were made at the strategic and tactical level. Control is a key activity, as it is needed to detect departures from the plan and to direct the attention of managers onto those areas that need immediate action.

### PLANNING FLEXIBILITY

What happens, in the hierarchical planning process described above, if one of the high-level strategic decisions turns out to be a mistake? As discussed above, control mechanisms are here to detect non-conformance to the plan and to trigger corrective managerial actions.

However, adjustments are only possible to a certain extent. For example, corrective actions may not be able to reverse the negative consequences of having invested in the wrong resource. To avoid those situations, planning can be improved by considering the concepts of *robustness* and *options*.

Driouchi, et al. (2009) describe robustness analysis as the process of distinguishing within a resource decision:

- The part of the decision which has to be made now.
- The further decisional options which can be made at a later time.

Their recommendation is to select the now-decisions which, when analysed in several different likely futures, can offer advantageous decisional options to address potential future problems. A robust decision is one which leads to satisfactory outcomes in all possible futures.

The **real options** approach requires planners to consider all the managerial options associated with the acquisition of a resource. Can the project be abandoned? Can the project be postponed? Through financial valuation techniques, the resource with the highest option value is the one that offers the most flexibility, and thus, the one that should be preferred in contexts where uncertainty and variability are high.

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# Integration

*Integration is the capability of providing a real time seamless co-ordination of processes within operations systems.*

## INTEGRATION SYSTEMS: FUNCTION AND FORM

Integration is a technology for **co-ordination**: the challenge of integration is to make sure that plans are executed smoothly, that any supporting information is exchanged at the right time without distortions, and that deviations from the plan are detected instantly, reported, and then acted upon. In the context of modern operations management, examples of high-level integration are best described through *Enterprise Resource Planning* (ERP) systems, which are large-scale, organisation-wide, information systems. They are the result of the parallel evolution of two distinct types of systems.

On the one hand, ERP is planning and resource allocation systems: as such these are similar in function to operations management systems such as Material Requirement Planning systems (MRP) and Manufacturing Planning Resource (MRPII) systems. MRPII systems, in addition to planning work orders, 'book' manufacturing resources to make sure that a plan is always feasible in practice. However, MRPII systems only produce plans for the use of manufacturing resources and do not address planning in other areas: will sufficient distribution capacity be in place to distribute the manufactured products? Through the same principles behind the design of MRPII systems, logistical managers will build and use a Distribution Resource Planning (DRP) system, but the

two systems are often used independent from each other, i.e. they are not integrated.

On the other hand, information managers can recognise the loss of efficiency incurred when operating stand-alone information systems. The accounting department, for example, may be able to produce better budgets if it had real-time access to the plans in the MRPII system. Similarly, the logistical function would benefit from accessing the MRPII system, as would the marketing function in order to produce better marketing plans.

ERP systems are information systems designed to integrate on a real-time basis the planning and management of all organisational resources under one unique system. When any organisational department creates a resource, or plans to acquire one, the entire organisation is immediately made aware of this decision. ERP systems cut through functional boundaries and also through hierarchical boundaries, as they are designed to support simultaneously the needs of staff, line managers, middle managers, and top managers.

Key leaders in the ERP industry are SAP, Oracle, PeopleSoft, Siebel, and Bann. As ERP systems truly integrate all functional areas together, implementing an ERP is a large-scale project. The typical cost of implementing a full ERP solution for a large organisation requires a few million Euros in hardware, about 30 million Euros in software, and at least 200 and up to 500 million in consulting fees. Why this high cost of implementation? Consider what an ERP does: it links together all the resource decisions across an organisation. This means that before implementing an ERP, all organisational members need to agree on the common processes by which they can make resource decisions. Tchokogue, et al. (2005) have documented an example of an implementation project at Pratt & Whitney Canada, and have stressed the organisational redesign which is necessary to achieve coherence and rigour across an organisation. Typically, organisations which do not have well integrated processes will experience major difficulties, or failures, at the implementation stage.

## ERP AND PROCESS MANAGEMENT

Take the example of a firm where cost accounting and manufacturing processes have historically been separated. Manufacturing and accounting may have an ongoing dispute about estimates of production costs and they may use two different sets of cost formulas to guide their decision

making. This is a typical scenario for an organisation with non-integrated processes. This means that an interfacing process should be designed, so that both functions can adequately feed data and information to each other. This is where ERP consultants come in. Their task is to map all the existing processes and to identify any gaps, redundancies and inconsistencies in this organisational-level process map. Once a reliable and effective process map is finalised, it can be formalised within the ERP system.

Some ERP consultants will go further and explain to clients that they are not purchasing an integrated information system, but a best-in-class set of processes. ERP consultants, through their various customers, can end up with a very good exposure to the variety of processes used by all competing firms within an industry. As such, it is easy for them to discover superior processes and to recommend these to firms in the same, or another, industries.

### ERP: OPERATIONS MANAGEMENT ISSUES

We have already seen that ERP systems deal with planning for resources and with designing the best processes for the utilisation of these resources: resource planning and process management are two central areas of operations management, and thus, the ERP-enabled organisation will have a great degree of its operations expertise embedded into their ERP system.

Beyond the question of process choice and planning capability, an often overlooked aspect of an ERP system is its natural control capability. An ERP system includes a detailed specification of all the work processes within a firm. For example, when a sales office accepts an order into the system, information about that order is passed immediately to accounting and production. When a production schedule is established information flows back to accounting and sales. When production is launched, this is entered into the system. When it is completed, this is again captured in the system, and all relevant parties are informed of its completion. This high level of real-time process visibility would be difficult, if not impossible, to achieve without an ERP system. Therefore, in addition to its planning capability, an ERP system is also an extremely powerful monitoring and control device. Control is an important step by which managers can address emerging problems and learn how to improve their plans, and therefore, one should expect that an ERP system would improve an organisation's responsiveness, synchronisation of actions, and planning skills.

At a management level, the large (integrated) databases that ERP systems use have also changed the degree to which real-time *detailed* information is available. In a traditional non-integrated information system architecture, the conventional wisdom was that line managers would work from detailed data and prepare summary reports. Middle managers would then work from the summary reports and prepare their own performance reports displaying only key performance indicators. These reports would then be sent to top managers. Not only can this reporting and aggregation of data be automated through an ERP system but also top managers then have the possibility of 'drilling down' onto detailed data at the click of the mouse to understand the root cause of a disappointing value for a performance indicator. For example, a top manager at the headquarters of a large multinational with 25 factories across the globe is now able to drill down to daily or hourly production and quality data from all those factories. Without an ERP, obtaining this type of data could have taken weeks.

Although the potential benefits of ERP from an operations performance perspective are impressive on paper, a word of caution is still necessary. Trott and Hoecht (2004) question the potential impact of the implementation of a rigid ERP system on innovation capabilities. They stress that limiting options to those available through a 'pull-down' menu could be very limiting in creative work environments. Similarly, Lengnick-Hall, et al. (2004) consider that many of the claims from ERP vendors are overstated. Although they recognise that ERP systems may be a necessity in order to co-ordinate very large and dispersed operations networks, they also argue that the capabilities attached to an ERP are not by themselves sufficient to guarantee that a firm will achieve a top competitive position in its industry. Their conclusion is that ERPs provide a platform for increasing social and intellectual capital but that in order to achieve a long-term competitive advantage, firms should do four things:

- Apply leverage to ERP connections to enhance the structural, relational, and cognitive dimensions of their social capital.
- Use their social capital to build their intellectual capital and thereby have a superior base of knowledge with which to compete.
- Be able to transform their ERP systems to conform to new insights or changes in the social system.
- Be able to transform their ERP systems to accommodate new avenues for competitive value that originate beyond current operations.

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## Risk

***Risk is the set of events and consequences, foreseeable or not, that occur, within or beyond the boundaries of an operations system, in reaction to the implementation of a plan of action.***

## RISK MANAGEMENT

Industrial engineering has always included in its subject matter the subject of product reliability and of product liability. At the moment *risk management* has become a 'hot' topic in business studies, a topic which has grown quickly especially in the field of finance. Simply put, *modern risk management is concerned with organisational exposure to volatility*. For example, a manufacturer may suffer from fluctuating raw materials prices, or a banker may suffer from fluctuating default rates on loans.

Operations management, quite surprisingly, has never been overly concerned with risk, at least from a theoretical perspective. There is indeed the industrial engineering heritage of product reliability and product liability, but these topics are often overlooked by lecturers and are not under the spotlight in operations management circles. This decline of product-related risk topics may be explained by the fact

that the technical origins of operations management meant that a lot of operations management theory has been primarily concerned with optimisation. Optimisation can take into account uncertainty, as for example when we add a safety stock (a probabilistic estimate) to an optimal inventory ordering policy. Lewis (2003) was the first operations management scholar to highlight that this variance approach to risk management is an oversight of operations management as a discipline. A safety stock gives a certain level of confidence that an organisation will not run short of inventory. However, it does not tell us what that organisation will do if it actually happens to run short of inventory. As Lewis (2003) points out, this later concern is more akin to a service quality problem, and represents the type of reflection that all operations managers should engage in.

### A MODEL OF OPERATIONAL RISK

In order to address the limited coverage of risk issues in operations management, Lewis (2003) uses four case studies to validate and improve a model of operational risk. The key elements of his model are causes, consequences, and control.

Causes are the events that can take place and have an impact on the performance of an operations system. Causes can be external or internal to an organisation. Lewis's research shows that causes are rarely independent and unique events. The failure of an operations system is more often explained by a chain reaction of events, which when taken together will cause an operational failure. Reconstructing or forecasting these possible chain reactions is an important aspect of risk management. Consequences are the outcomes of the causes. Lewis's case studies show that such consequences are dynamic rather than static, i.e. they evolve over time: a consequence may lead to more consequences later on. Finally, consequences will affect a variety of stakeholders as these can be internal (e.g., a machine breakdown) or external (e.g., they can have an impact on the customer, the parties connected to the customer, or other parties such as the local community).

Controls are the mechanisms that operations managers can use to implement a risk management initiative. Lewis (2003) distinguishes three types of control: *ex-ante*, in process, and *post-ex*. *Ex-ante* controls are preventive risk management controls. They try to anticipate the occurrence of risky situations. The use of safety stock for inventory,

design validating schemes such as value engineering and failure mode effect analysis (FMEA), the project risk analysis management (PRAM) framework, the use of options thinking (see **Real options**), quality assurance certifications, and suppliers audits are all examples of *ex-ante* controls.

In-process controls are mechanisms to address a risk occurring live in an operation system. As it is too late to prevent the risk event, the purpose becomes to mitigate the potential negative consequences of that event. The inspection of incoming goods is an example of an in-process mechanism. Switching options is another example. A switching option gives a facility the possibility of switching inputs (for example, for a cheaper raw material), processes (for example, for a factory where favourable exchange rate conditions increase cost efficiency), or outputs (for example, the ability to stop producing a low demand item to produce a more popular item). Operational policies should incorporate guidelines for dealing with incidents such as fires, earthquakes, or other catastrophes having an impact on the operations of an organisation.

Finally, *post-ex* mechanisms correspond to the notion of service recovery in service quality management. The concept of service recovery can be extended to potentially more serious interventions such as a product recall or the abandonment of a project. Finally, an important area for post-ex mechanisms is *disaster recovery*.

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# Theory

***Theories are tools composed of a set of laws used to make sense of a phenomenon.***



## THEORY IN OPERATIONS MANAGEMENT

Schmenner and Swink (1998), among others, are two authors who have expressed concerns about the apparent lack of theory in operations management. However, they suggest that operations management researchers may have been too harsh on themselves as an examination of the operations management literature reveals a number of extant theories. The purpose of this concept is to discuss two theoretical aspects of operations management. In the first section, we discuss how operations management research uses, informs and complements economic theories. In the second section, we draw an inventory of operations management theories and indicate in which concepts they are discussed.

### OPERATIONS MANAGEMENT AND ECONOMIC THEORY

In concept 1, we have developed a theory of operations management starting from Coase's theory of the firm. It is important to realise that in economics, there is not one unique theory of the firm. Over the years, economists have instead developed several 'theories of the firm'. These theories are presented in the following sub-sections. In each case, we indicate their relationship to operations management research.

#### The neo-classical theory of the firm

This theory is behind the standard view of the firm as a form of economic organisation seeking to maximise profitability. Kantarellis (2007) summarises the neo-classical theory of the firm by explaining that from the study of demand and supply functions, the theory makes predictions about the behaviour of markets and identifies optimal strategies for firms. Although this theory treats the firm as a 'black box', it describes many phenomena, such as economies of scale and economies of scope, which are central to many operations management decisions (such as operations strategy and capacity decisions). Moreover, it is because of that fact that the neo-classical theory of the firm treats the firm as a black box that operations management, a discipline which concentrates on the system within the box, can inform and enrich economics.

#### The managerial theory of the firm

The key contribution of this school is *agency theory*, where the differences between the principals (owners) and agents (managers) of the firm are

explicitly recognised. Theories of contracting are important in this area and a lot of the research in **supply chain** management is based on agency theory.

### The behavioural theory of the firm

Formulated by Cyert and March (1963), the behavioural theory of the firm challenges the neo-classical view and points out that managers have neither the omniscience nor the time to maximise the profits of the firm. In practice, managers have to act on incomplete information and instead of optimising they spend their time *searching* for better solutions and improvements. Instead of being the exercise of rational decision making, managerial decisions are the result of group behaviour. Powell and Johnson (1980) were the first to question the lack of behavioural variables in operations management research. They proposed an expectancy-equity model of productive system performance to show how behaviour variables can be taken into account. More recently, Bendoly, et al. (2006) argued that the theory-practice gap in operations management is often explained by behavioural issues (how people perceive, react, and work in the workplace). Their literature review provides a summary of twenty years of research about behavioural operations management.

### Transaction cost theory

Transaction cost theory (Williamson, 1985), the direct extension of Coase's ideas about the nature of the firm, deals with the choice of a mode of governance of economic transactions. Three alternatives for governance exist:

- Hierarchical governance: Where a firm prefers to internalise the production of an asset.
- Market governance: Where a firm prefers to rely on the price mechanism and market forces to source a product.
- The hybrid governance mode: Where a firm enters into a partnership or joint-venture with its supplier to secure the provision of an asset.

Transaction cost theory plays an important role in process strategy when operations managers are asked whether or not a process should be

outsourced (see **Outsourcing**). Similarly, transaction cost theory plays an important role in understanding **supply chain** relationships.

## EVOLUTIONARY THEORY OF THE FIRM

Departing from the static view of the firm in the neo-classical view, this theory holds that firms hold capabilities allowing them to deploy their resources in competitive markets. This means that in a response to change firms may design new capabilities (e.g. new processes) which will create entirely new economic sectors and industries.

Evolutionary matters are dealt with at two levels in operations management. At a practical level, a number of operations management concepts are about innovation and change (see **Management Innovation, Process Management and Kaizen**). At a theoretical level, the theory of evolution can be used to explain past changes and the current conditions within an industry structure. For example, Leseure (2000) presents the evolutionary history of operations management systems in the hand tools industry and its implication on manufacturing strategies.

## THEORIES IN OPERATIONS MANAGEMENT

Key theories in operations management are:

- The theory of **operations** management.
- **System** theory.
- Contact theory (see **Customers**)
- **Co-ordination** theory.
- The theory of performance frontiers (see **Trade-offs**).
- The theory of swift, even flow (see **Just-in-Time-Inventory**).
- The theory of constraints (see **Throughput**).

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