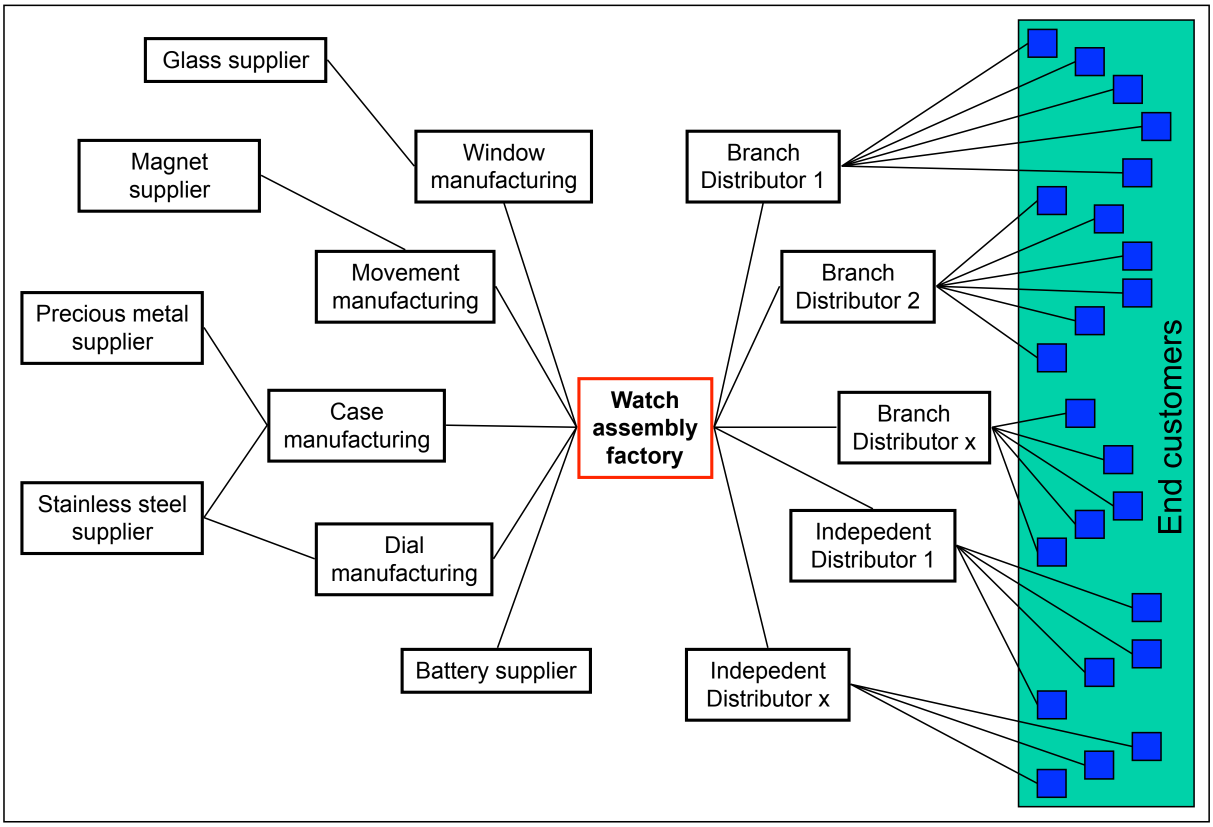
EPFL: Course ME-419

Production Management

Chap 1, Introduction

For any company, independently of its size and location, competition has to be looked at globally. Information and communication technology and transportation systems allow firms to purchase, manufacture, assemble, sub-contract, store, sell, etc. almost anywhere. Of course, although the best solution is not always found in distant locations, a global view of operations is necessary. *Production Systems* therefore need to be considered as a group of elements adding value to materials for customers. The value adding elements (suppliers, machine shops, assembly factories, etc…), called centres or nodes, form a network in which material and information flow between them. The figure below shows a simplified representation of the *Value Adding Network (VAN)* of a watch manufacturer.



Simplified representation of the *Value Adding Network (VAN)* of a watch manufacturer.

The extend of a true *Supply Chain Management (SCM)* approach in the *VAN* of the previous figure, i.e. the limit of the network that would really be involved in a common search for global performance improvement is not obvious to define. In practical cases, this will depend on the type of relations that exist between the different *VAN* partners. In the previous simplified example of a watch maker, it is likely that the case manufacturer would be included within a *SCM* approach because the business relationship between the watch assembly factory and the case manufacturer is of equal importance to both of them. It is also likely that the same would hold for the relation between the case manufacturer and the precious metal supplier. On the contrary, it is very unlikely that the stainless steel supplier would be included in a *SCM* approach as the case manufacturer business is probably not significant for it.

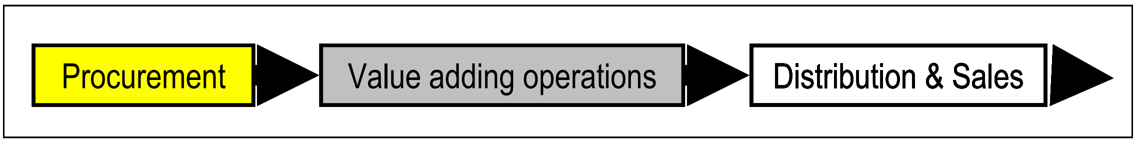
The better this network performs, the better the value created for the final customers. This requires of course on the one hand that each of the elements of the network has a sufficient performance level and on the other hand that the network itself performs correctly. This somehow theoretical description leads us to the following more practical points:

– Each value adding element contributing to the Value Adding Network must be organised and managed so as to perform its tasks as efficiently as possible.
– Each value adding element contributing to the Value Adding Network must be organised and managed so as to contribute as much as possible to the performance of the Value Adding Network itself.
– The Value Adding Network must be organised and managed so as to deliver the best possible performance to the end customer.

Traditionally, the first point is treated in production and operations management, while the last one is generally called *Supply Chain Management.*

In this Production Management course, we will consider the organisation and management of the operations of a company as part of a *Value Adding Network*. We will therefore not consider pure *Supply Chain Management*, but take it into account in looking at the production and operations management of a company as part of a *VAN*. In other words, we will look at one node of the *VAN* and see how to organise and manage its operations to get the required performances.

Each node of the *VAN* can be roughly described as shown in the next figure.



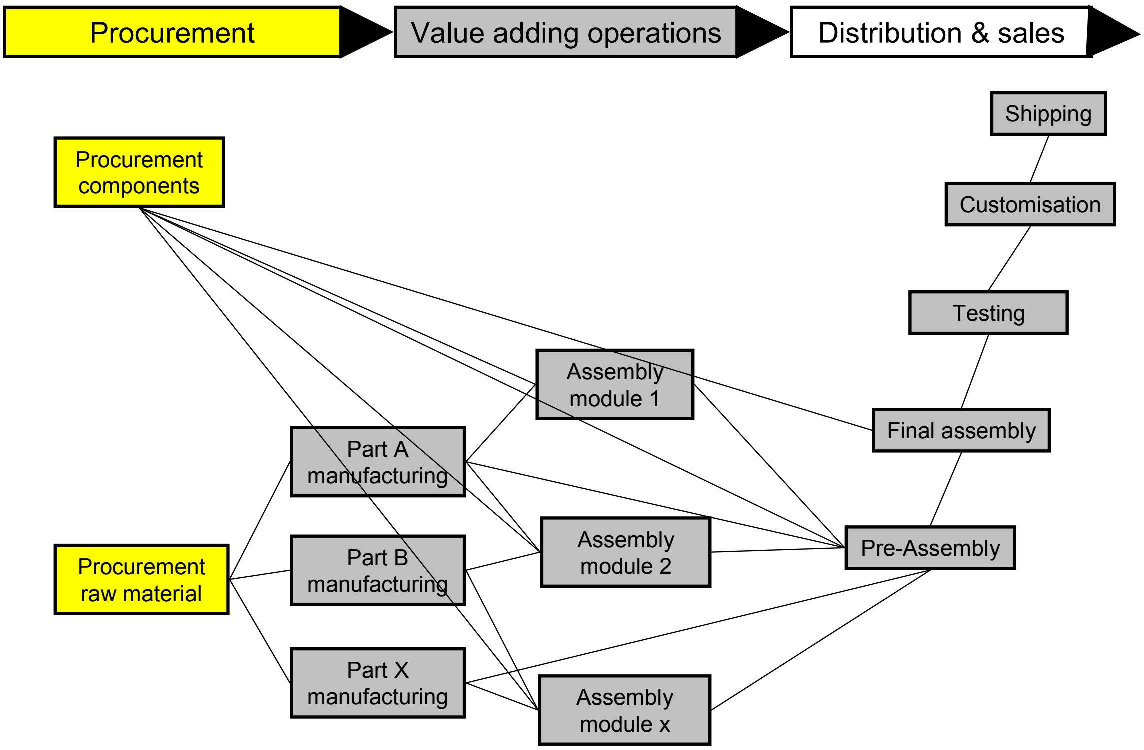
Schematic representation of the main activity groups in a node (company within a *VAN*)

The core is a set of value adding operations that requires procurement activities to assure the inflow of material and outflow of information and distribution/sales functions which in turn assure the outflow of material and the inflow of information. The core value adding operations are realised by a network of production units as schematically shown by the next figure.

As illustrated by this figure, the internal *Value Adding Network* of a node is similar in its structure to the global *VAN*. This structural similarity is one of the characteristics that have led to the concept of the fractal company[1].

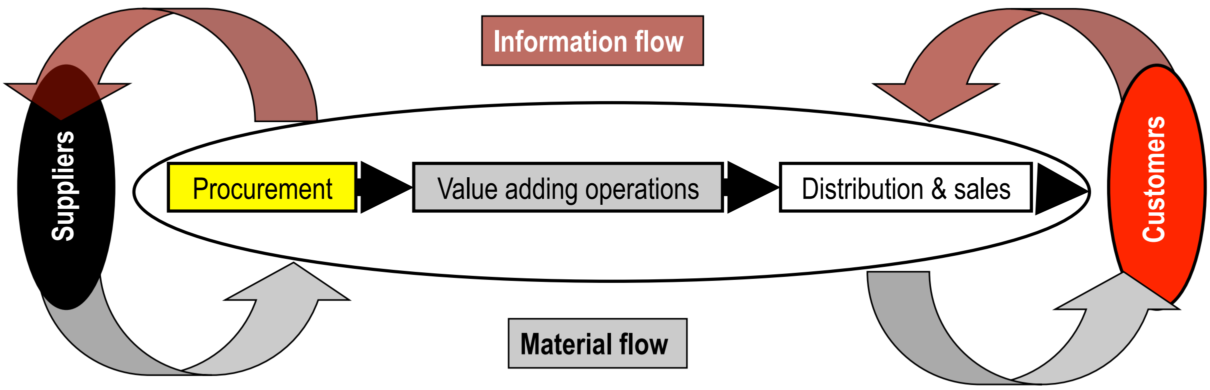
[1] Warnecke, H.-J. (1993) ; ''The Fractal Company a Revolution in Corporate Culture'' ; Springer-Verlag

The internal *VAN* must first be designed, i.e. the nodes and the interactions between them must be specified: what is done where, where the operations are executed, where the stocks are located, etc… However, this system design phase is not the subject of this course; here we consider that the production system exists already (it has been designed and implanted in the past) and we will concentrate on how to select its appropriate management parameters and how to manage it in a fast changing environment.



Internal value adding network of a node

Considering the interactions of the node with its environment, the exchanges of material and information must be considered. The node can then be schematically represented as shown in the next figure (obviously, the value adding operations are actually a network, as discussed above).



Schematic representation of a node (company within a VAN) with its material and information flows linking it to its environment

This representation provides the framework of this course; accordingly, we will look at the following main points:

- How to mine useful information out of historical data in order to plan for future needs?
- How to plan operations in order to fulfil future market demand?
- How to manage and calculate inventories?
- How to execute operations and organize the material and information flows in order to respond efficiently to market demand?

1.1 Content & program of the course

In order to provide an answer to the previous points, the course is structured as follows:

Chap.1	Introduction
Chap. 2	Basic concepts and definitions
Chap. 3	Demand Management, Forecasting
Chap. 4	Production Planning & Control
Chap. 5	Inventory management
Chap. 6	Just in Time & Lean Manufacturing

The success of the course requires the active participation of students and is based on four main elements:

- Individual self-learning by reading documents;
- Group learning by studying and summarising course material;
- Learning through professor's presentations and discussions;
- Group learning by solving application cases.

The course program is covered according to a weekly schedule that is not included in this document but will be made available to students.

The weekly schedule must be taken as a broad guideline as flexibility must be allowed for more intensive discussions of some specific points, increased time for group work, etc…

1.2 Economic & business environment

Production or manufacturing (both terms are equally used) constitutes a key element of a modern economy. The following citation, although quite old, still holds for any developed country. It was written in 1995 by Professor Iain Finnie, Chairman of a US National Research Committee in the introduction to an official published report[2].

> ''Unless, we as a nation consider manufacturing as important as fundamental science, health, social programs, and national security, we will not be able to generate the resources necessary to pay for our investments in these factors which contribute to our standard of living.''
>
> IAIN FINNIE, chairman
>
> Unit Manufacturing Process Research Committee
>
> US National Research Council, Jan. 1995

From an historical point of view, production dates back to the first attempt by mankind to transform natural raw materials (stone) to improve their suitability for a given use (for example hunting). Since the first half of the 20th century, the business environment has drastically changed due to the modification of the power relationship between producer/customer and to the development of transportation and information exchange.

To emphasise the characteristics of the current business environment, let's first look back at two historical situations: a society based on agriculture (Egypt 2000 B.C.) and a society based in industry but with much stronger demand than supply (the 1930s):

Economy based on agriculture:	**Industrial economy with insufficient offer:**
7 years of good production / 7 years of weak production	
… meat storing in salt	*'The customer can have any color he likes as long as it is black'*
… fruit preservation by drying	*Henry Ford*
… storing of hay for the winter	
… etc.	
Need to satisfy a stable demand, fed by a variable production.	Need to satisfy a variable demand, fed by a stable production.

In the oldest case, the demand for food was essentially stable, but production was irregular and unpredictable (not to mention the annual seasonal variations). It was therefore vital to store food in inventories to avoid food shortages as much as possible.

In the 20th century case, market demand was much larger than production capacity, competition between car manufacturers in the 1930s was very limited and the customer had almost no power. He or she had no choice but to wait for a product whose price and characteristics (colour ...) were decided by the producer alone.

Since that time, the situation has reversed in almost all economic areas. The business environment of the beginning of the 21st century is characterised by the elements presented in the next figure.

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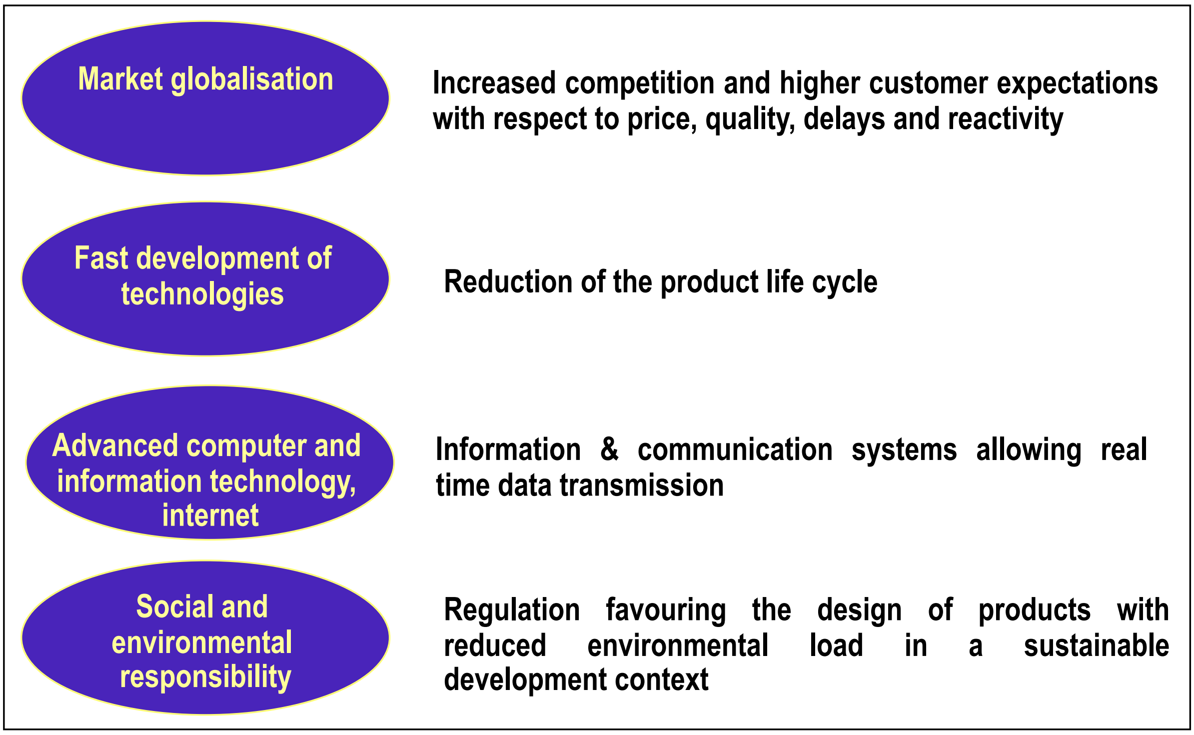
[2] Unit Manufacturing Processes, Issues and Opportunities in Research, National Academic Press, Washington, D.C. 1995, ISBN 0-309-05192-4

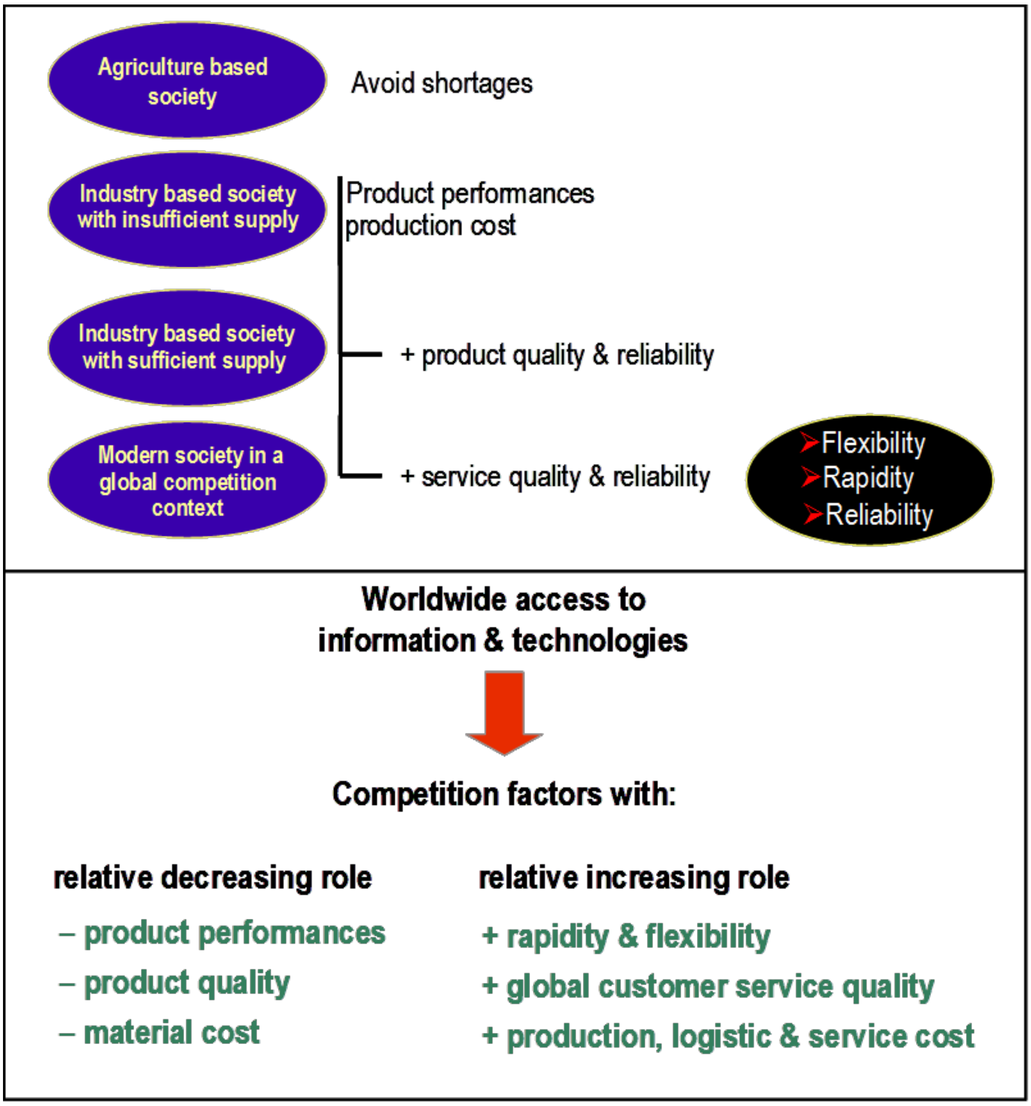


Current evolution of the business environment

These evolutions have led to more intensive competition on the market in a global context. The later point means that a customer can today find its supplier anywhere in the world. The consequences of this situation are in particular:

- An increase of product variety (i.e. larger number of different products);
- A reduction of the volume per product;
- A higher variability of demand;
- Shorter expected delivery delays;
- Higher expected delivery reliability;
- Pressure for total cost reduction.

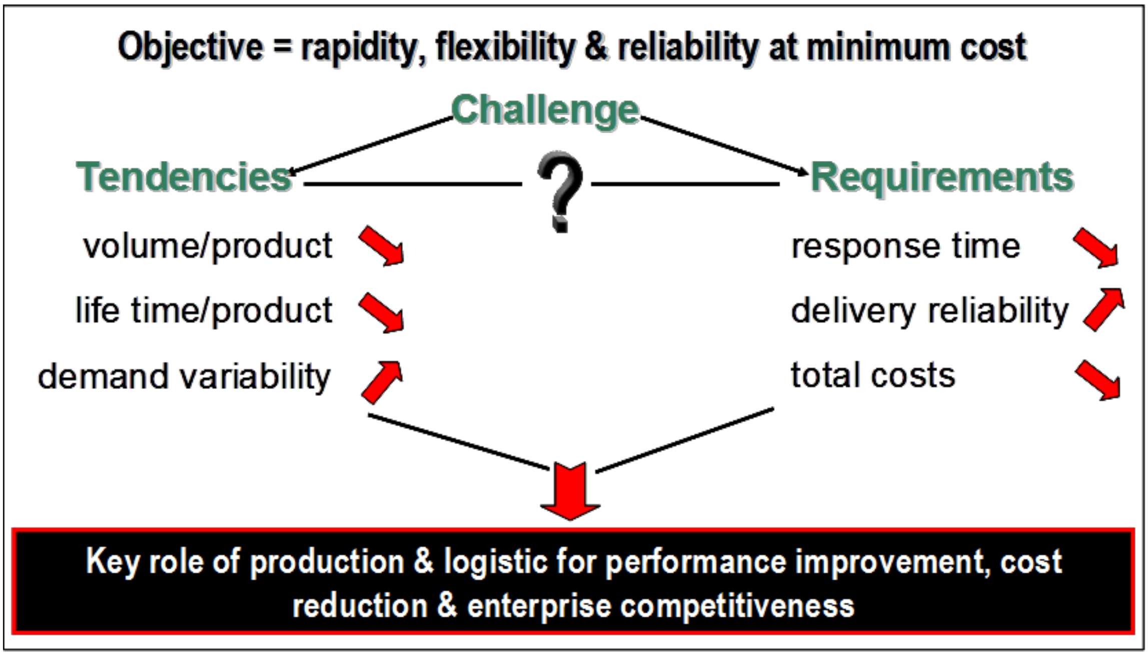
Consequently, the competition environment has drastically changed as illustrated by the figure below. Technology, and increasingly technological know-how are available worldwide, product quality and reliability are standard and no longer an effective factor of differentiation. The same is also increasingly true for product technological performances that can be imitated and quickly surpassed by a competitor. Therefore, product performance, quality and reliability are today necessary but not sufficient to remain competitive. Organisational excellence leading to high service quality and reliability (short and reliable delivery delay, organisational and technological flexibility) are becoming key differentiation factors. This trend is schematically illustrated by the next figure.



Evolution of the competition differentiation factors

The combination of the trends mentioned previously regarding product volume, variety and life cycle with the changing market expectations gives manufacturing enterprises a very difficult challenge as these two sets of parameters evolve in a conflicting way. This particularly difficult situation is illustrated by the next figure. In such a context, the organisational excellence of the company, and in particular, the performances of its production and logistic system constitute decisive elements for a firm's competitiveness.

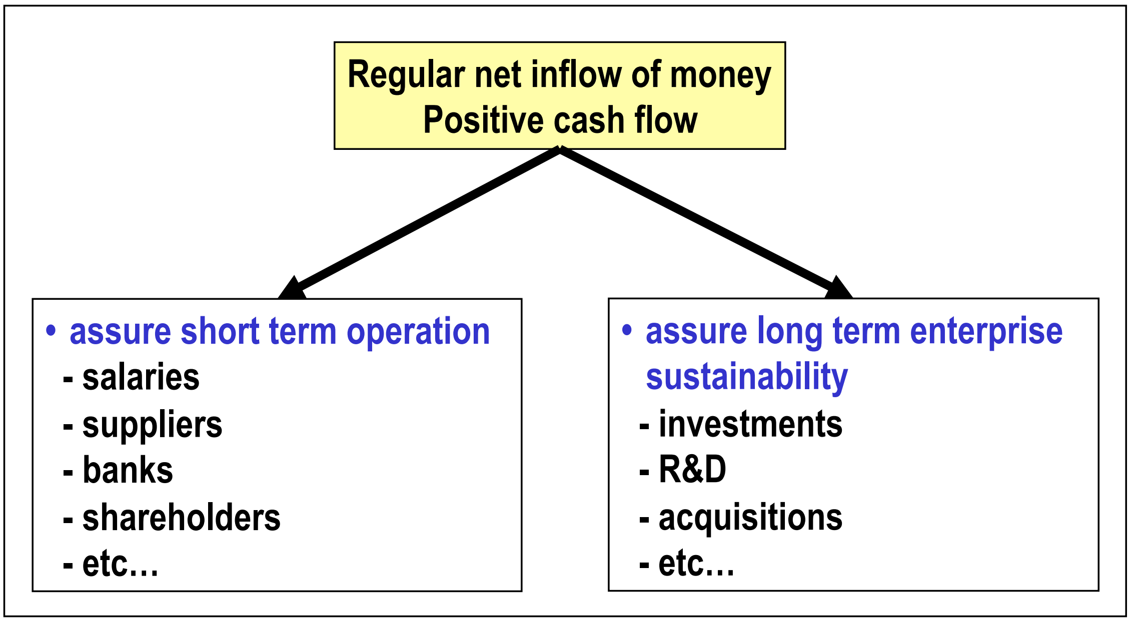
A company able to master this challenge possesses a very effective competitive advantage as it is both difficult to identify and impossible to copy. Creating organisational excellence and building up a high performance production & logistic system is a long, risky and difficult process. However, once it is achieved, the resulting competitive advantage is then much more robust and long lasting than any technological product innovation that can be quickly copied.



Enterprise organisational challenge and key role of production & logistic

1.3 The manufacturing firm

The primary objective of a firm is to assure its short and long term development. For this purpose, it needs a regular net inflow of money, a positive *cash flow*. The following figure schematically illustrates the short and long term aspects of this situation.

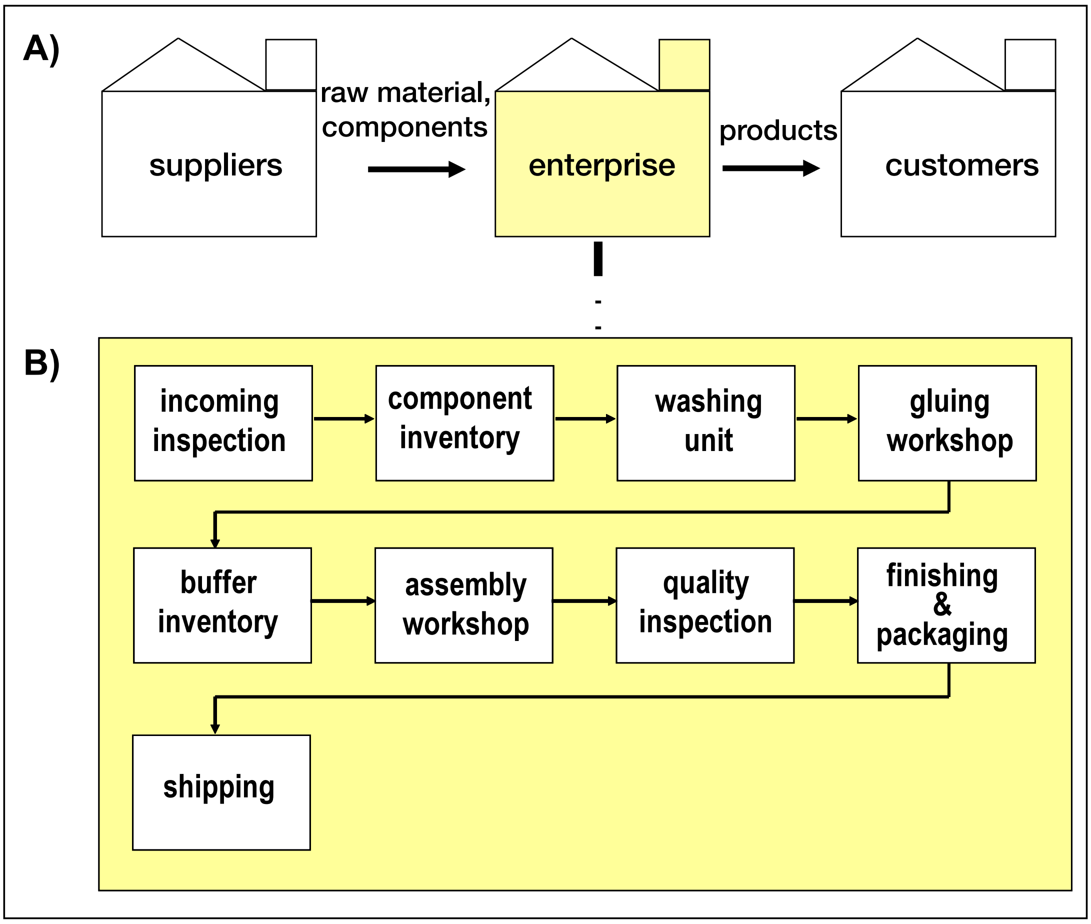


Enterprise primary objective: assure short and long term development

A manufacturing enterprise can be described (in a macroscopic way) as being characterized by three flows and two cycles as indicated by the following table.

Three flows:	**Two cycles:**
Material flow	Product life cycle
Information flow	Production & logistic cycle
Financial flow	

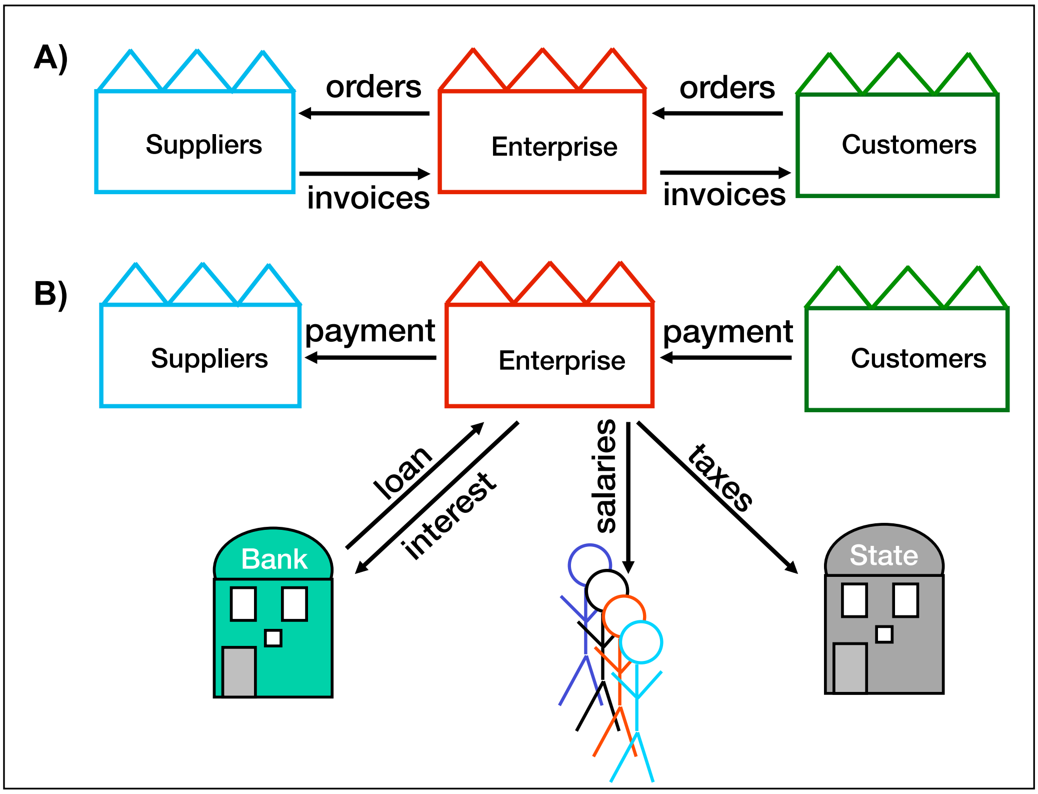
The material flow extends from the various suppliers down to the final customers. Because of the analogy with water flowing in a river, the terminology upstream and downstream are often used to describe the parts of the material flow towards suppliers and towards customers respectively. In this course, we will systematically represent the material flowing from left to right, i.e. the upstream part on the left hand side, the downstream part on the right hand side. The following figure provides a schematic representation of the material flow. In part A with a global view from suppliers to customers and in part B within the manufacturing company itself.



Enterprise material flow

The information flow extends similarly from customers to suppliers. Customers send orders to the company which also places orders to its suppliers. This information about product demand (demand forecast, firm orders, order modifications …) flows in the opposite direction with respect to the material flow; from the downstream part to the upstream part of the *VAN.* It provides the data required to plan and run the *VAN.* Other data such as invoices, flow in the opposite direction as shown in the next figure part A.

The financial flow, also going from the customers to the suppliers, further extends to other financial partners of the enterprise such as employees, banks, shareholders, the state… The financial flow can be quite complex, much more than schematically represented in part B of the following figure.



Enterprise information (A) and financial (B) flows

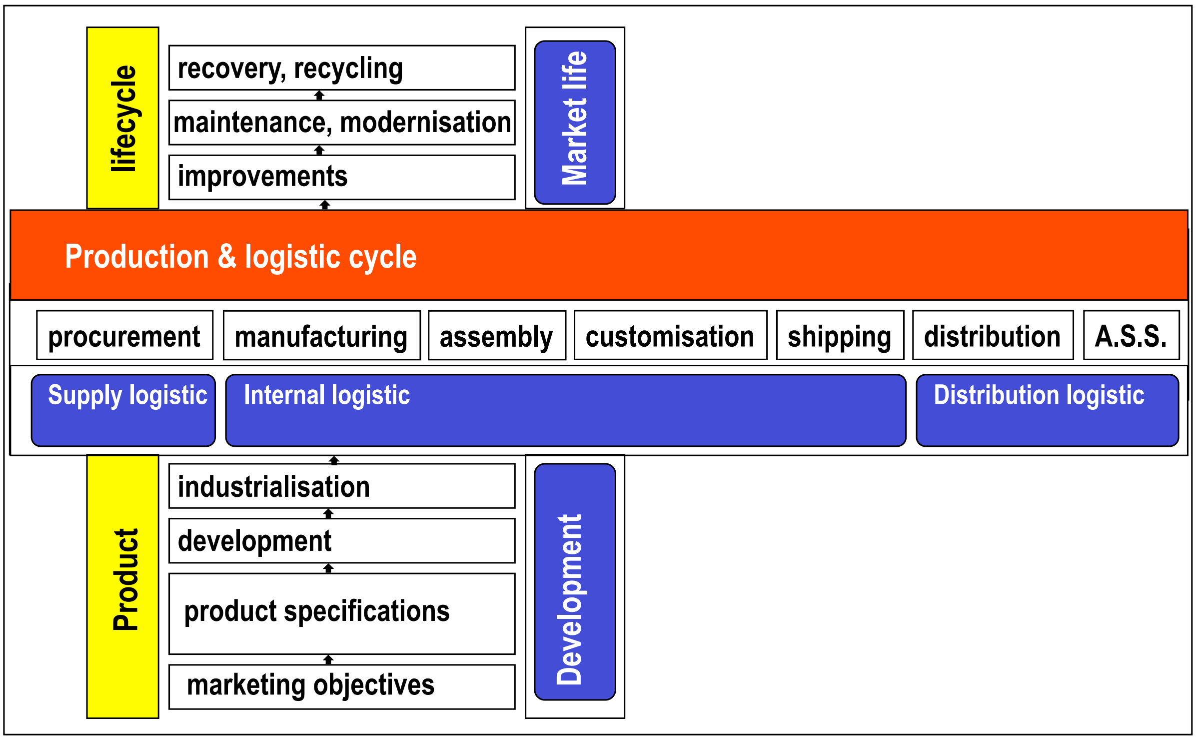
The two cycles, as illustrated by the next figure, are linked to the product lifecycle on the one hand and to the value adding operations on the other.

The product lifecycle starts with the market study that identifies the product needs and characteristics. It ends with the end of life management of the product. In a manufacturing enterprise several products and product families live simultaneously at different stages of their lifecycle. Some new products may still be in the development stage, not available on the market; others may be being phased out of the market while others may be at the peak of their production volume.

The production & logistic cycle starts with procurement activities and ends with after sales services. Therefore, it covers the whole value adding operation chain.

These two cycles are quite different. The product life cycle lasts over a period of several months (consumer electronic products for example) to several years (heavy machinery, automobiles for example). If quantified by the output material flow, it starts with a zero phase until market introduction, goes through a growing phase, stabilisation and final decrease, the so called life cycle curve. The production & logistic cycle on the contrary is characterised by a much shorter period (defined here as the duration between material inflow and material outflow), which usually lasts a few hours (industrial bakery for example) to a few months (heavy machinery industry for example). This characteristic time (outflow date – inflow date) plays a very important role in manufacturing management and is called the total *lead-time*. The *lead-time* is a central concept that will be used and discussed many times in further chapters.

The intensity of the material flow of a given product or product family within the production & logistic cycle is directly linked to its product lifecycle. Actually, it follows the lifecycle curve mentioned earlier. Therefore, the product lifecycle can be seen as controlling the intensity of the material flow within the production & logistic cycle.



Two cycles: product life cycle + production & logistic cycle

1.4 The systems engineering view of the manufacturing enterprise.

According to systems engineering, a system can be defined as a set of elements belonging to and interacting with each other, both inside the system as well as with its environment. A system is essentially defined by:

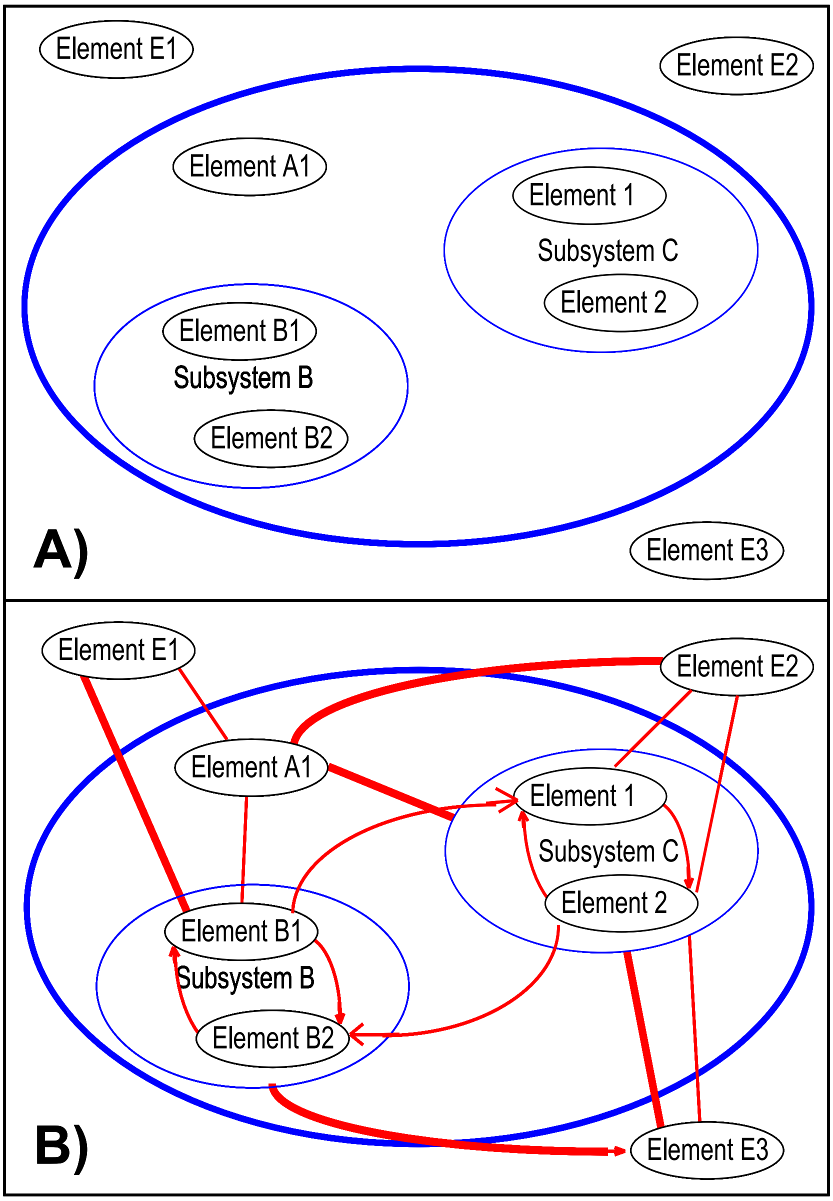
- Its constitutive elements;
- Relations between these elements;
- The borders of the system.

The structure of the system is defined by the number and the nature of the constitutive elements and by the borders of the system and possibly subsystems, as illustrated by the next figure, part A.

The organisation of the system is determined by the links between the various constitutive elements, within the system's borders as well as with elements of its environment, i.e. outside its borders (see next figure part B).

The operational flows are given by the nature and intensity of the links between the elements.

In the case of a manufacturing enterprise, the elements represent operational centres (the nodes of the *VAN*) and the links represent the three flows (material, information and financial). The operational flows will then define the type of exchange and its intensity, the flow rate.



Schematic representation of a system: A) structure, B) organisation

The structure and organisation of the system evolve discontinuously, by single steps in a discrete way. In practice and in the case of a manufacturing enterprise, this is done in a well-planned way through project organisation and carefully managed using project management methods. Typical examples could be the replacement of a supplier or the introduction of a new operations management method such as *Just in Time (JIT)*.

On the contrary, operational flows continuously change in real time. In the manufacturing enterprise they are managed in a continuous way using production management methods. The goal of these methods is to control the flows (nature and intensity) so as to offer the best performance at minimal cost. Typical examples are the management of the upstream material flow from suppliers, the control of the information flow from subsidiaries, etc…

In other words, the structure and organisation can be seen as the ''how'' and the control of the operational flows as the ''what'' of the system's management. The characteristics of the system approach briefly presented above are summarised in the next figure.

How ?	What?
Concerns: structure/organisation	Concerns: operational flows
Project management	Continuous production management (MRP, Kanban...)
Actions: unique non repetitive time limited financially limited ad hoc organisation	Actions: continuous repetitive no fixed limits productivity objectives stable organisation
Examples: enterprise reengineering product development supplier replacement	Examples: supermarket electronic component production automotive assembly line

System view of the manufacturing enterprise; summary

1.5 Table of contents

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