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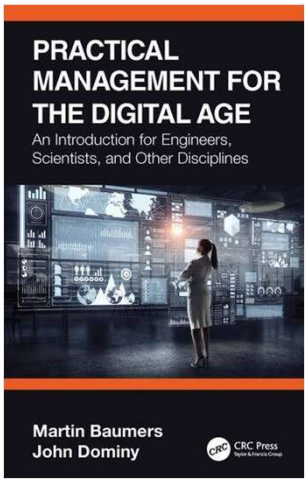
Department of Mechanical, Materials and Manufacturing Engineering

Operations management

What we will talk about today:

Operations management

- *Definition and overview*
- *The functions of operations management*
- *Different types of operations processes*
- *Supply chain management*
- *Different supply chain structures*
- *Demand forecasting*
- *Enterprise resource planning systems*



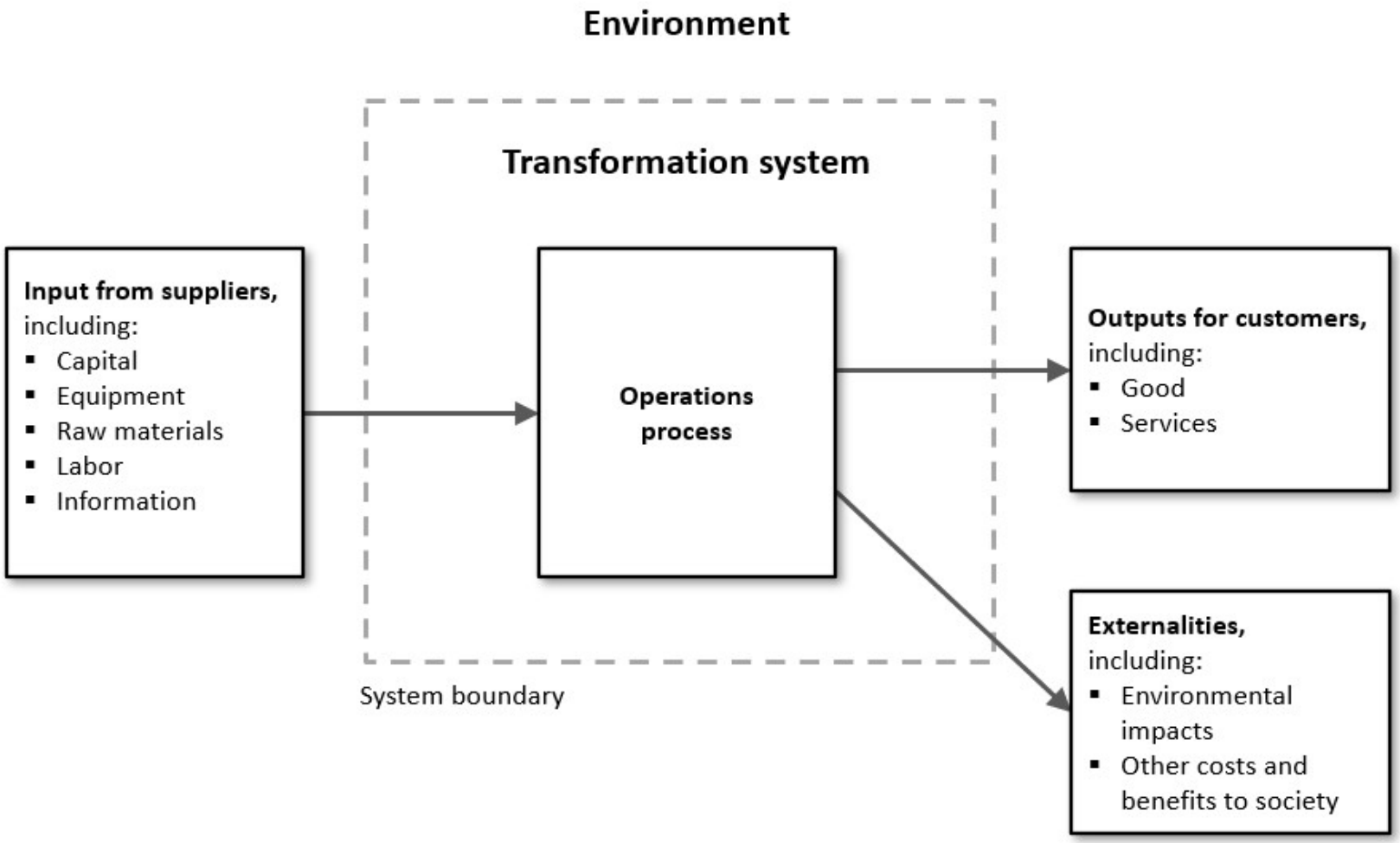
Lecture builds on Chapter 9 in Baumers and Dominy (2021)

Definition of *OPERATIONS MANAGEMENT*

"Operations management is the set of activities, decisions and responsibilities relating to the management of the delivery of products and services."

- Operations managers often have backgrounds in engineering!

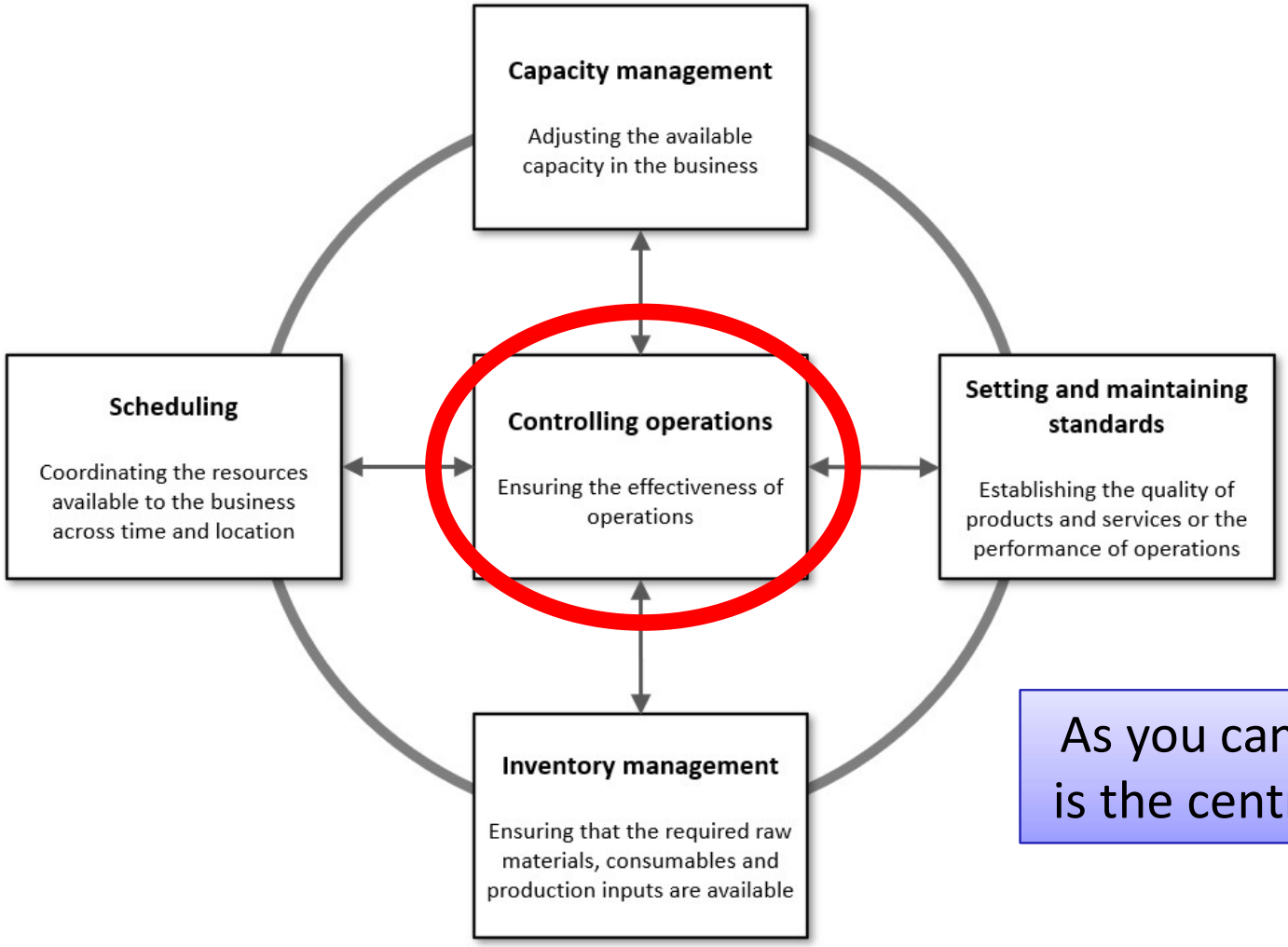
A systems view on operations management



- This is a very general but helpful model…

What functions does operations management incorporate?

There are many different classifications, a common one concentrates on five important functions:

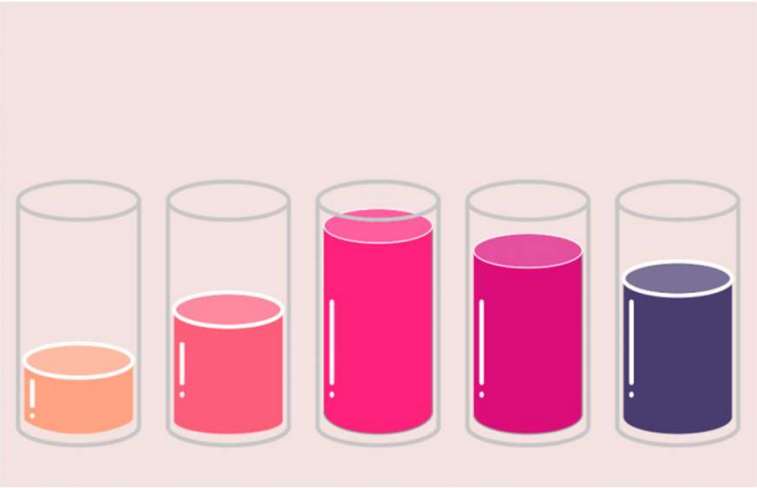


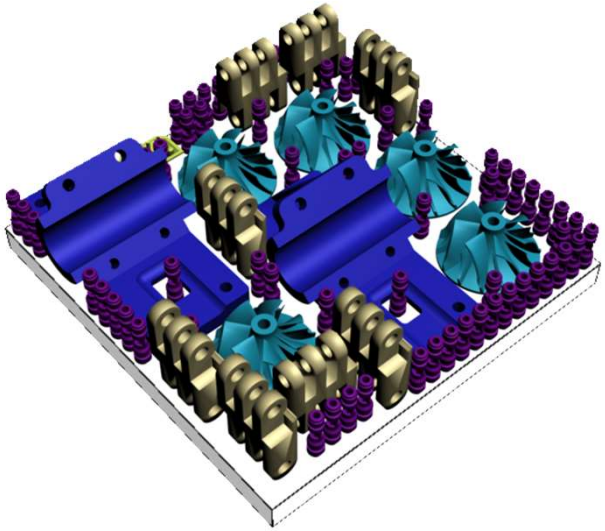
As you can see, control is the central function…

Capacity management

Any operation has an upper limit for the production of outputs, be they products or services.

- This limit is known as the *nominal capacity* of an operation.
- Operations systems can be run above this capacity, but not for long.
- Making decisions about capacity is an important activity for senior operations managers.





Setting and maintaining standards

In operation management, performance standards normally concentrate on how long the completion of the various processes carried out in the business should take and how well these are performed.

- An important metric is *Overall Equipment Effectiveness (OEE),* discussed in the Lean lecture.

- The management of quality standards forms a separate topic.

Inventory management

An important function of operations management is to make sure that the necessary raw materials, consumables and other production inputs are available for the productive processes to be carried out.

"Inventory is the stock of the objects held by a business ready for use or processing, including raw materials, components, assemblies, intermediate products and finished products."

Holding more inventory gives safety in case of disruption

Holding more inventory is costly and risky

Scheduling

The activity of coordinating the resources available in the operations of a business across time and location is referred to as *scheduling*.

- Takes into account information about the *order flow* received by the business and matches this flow to the available capacity
- Generally done across three "*time horizons*":

<5 years into the future:	< a few months into the future:	Immediate scheduling:
AGGREGATE SCHEDULING	**MASTER SCHEDULING**	**DISPATCHING**
(basis for capacity planning)		

Controlling operations

The control function in operations management controls the other operations activities in the business. Without such control, the effectiveness of the other operations functions would be severely diminished. The general control cycle for operations processes consists of four phases:

- Setting the criteria, standards and objectives for operations processes
- Measuring the state and performance of individual processes
- Comparing the measured data to expectations
- Acting decisively in different time horizons to bring the process in line with objectives

Different types of operations processes

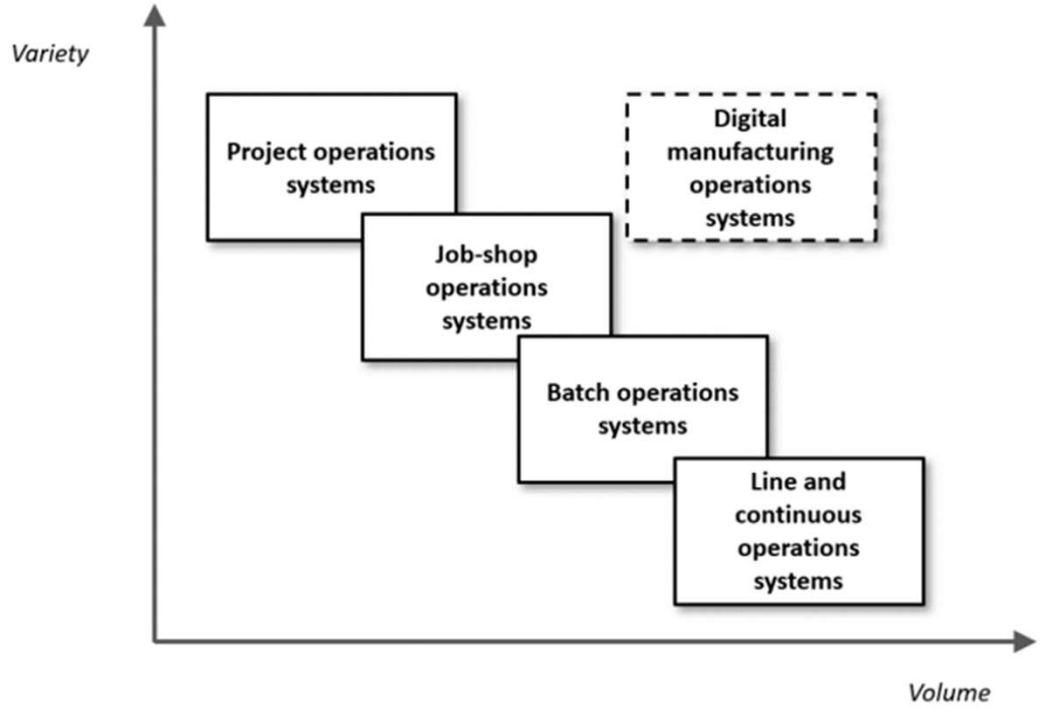
A task of significant practical importance faced by senior operations managers and the leadership of the business is making decisions on how the operations functions required by the business should be structured.

- An important aspects in this is the “span” of operations
- Some businesses have a large span of operations, others have a minimal span of operations

Production systems

In the production of physical, tangible products (as opposed to services), a range of different types of *operations systems* can be identified:

- The traditional framework for this is the product-process matrix by Hayes and Wheelwright (1979)



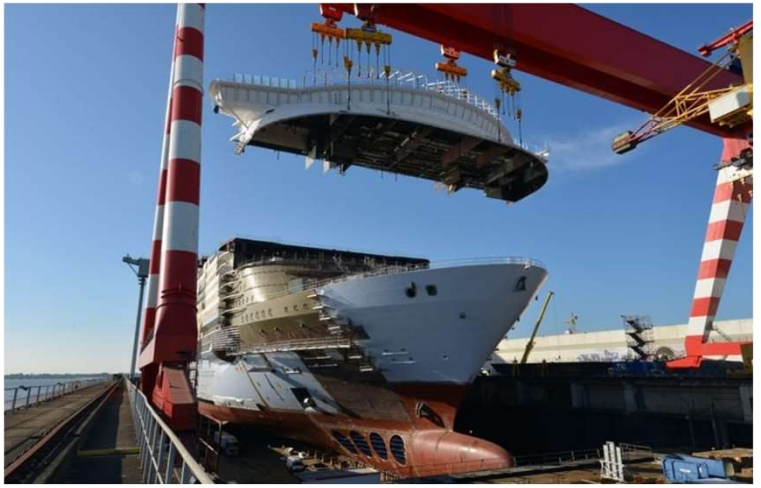
Project operations systems

Characterized by:

- Small volume of products (sometimes a single unit)
- High variety
- Work in parallel
- Product often stationary
- Complex organizational task
- Involves expensive and highly specialized workers

Example industries:

- Marine engineering
- Construction
- Bespoke software
- Film making
- …



Job shop operations systems

Characterized by:

- Small volume of specialized products
- Often making use of general-purpose tooling
- Usually involves highly-skilled workers
- Planning job shops is difficult due to irregularity and uncertainty

Example industries:

- Industrial equipment manufacturing
- Printed products
- Small scale aviation
- ….

PORTLAND PRINTING CO.

Cessna
A Textron Company

Batch operations systems

Characterized by:

- Larger volumes of products
- Often employing flexible manufacturing systems
- Often use pre-planned and documented technologies
- Worker activities in small, incremental steps
- Mix of workers with different skills

Example industries:

- Automotive components.
- Office furniture.
- …

Line and continuous operations systems

Characterized by:

- Large and very large volumes of products
- High degree of automation
- Mainly unskilled workforce
- Low flexibility and variety
- Distinction between *integral products* → line operations system, and *dimensional products* → continuous operations

Example industries:

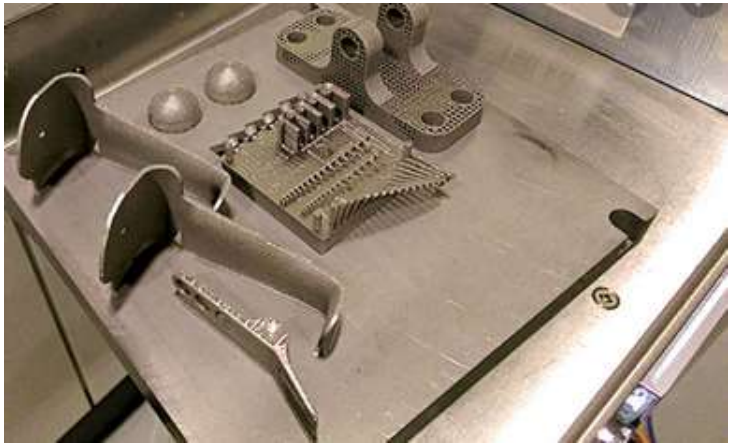
- Car production
- Consumer electronics
- Chemical industry
- …

Future operations: digital manufacturing

As the result of the embedding of information technology in manufacturing, digital manufacturing refers to new manufacturing processes incorporating information technologies as well as the production operations system enabled by these technologies

- Also referred to as *Industrie 4.0* or the *smart factory*

- Using modelling, analysis, simulation and real time control of all equipment used in the factory to optimize efficiency, thereby enabling unprecedented flexibility and low cost



Example industries (early adopters):

- Aerospace
- Defence
- Medical
- …

What about services?

Can be thought of in a similar way to production systems. Again, not always clearly distinguishable onto different categories, three broad archetypes for service operations systems are normally delineated:

1. *Professional service systems*

- Highly customized, delivered by experts, often professionals.
- Examples: Medical doctors, lawyers, accountants, etc.

2. Service shop systems and service factory systems

- Intermediate customization and volumes, delivered by semi-skilled workers.
- Examples: Hotels, estate agents, car repair shops, etc.

3. *Mass service systems*

- High and highest volume, automated where possible, low-skilled workers.
- Examples: Consumer-facing online, mass transportation, supermarket retail, etc.

The role of technology in shaping the volume-variety trade-off

The distinction between different operations systems is itself largely due to limitations in technology:

- The significant decline of the costs of information technology has enabled digital mass service operations based on the provision of standardized and fully automated, yet highly personal, services (e.g. social media);

- The emergence of flexible manufacturing systems in the second half of the twentieth century, has allowed many new applications for batch operations systems;

- Mass customization systems allow the creation of products which are modified to meet specific customer preferences in large volumes. This was achieved through a process of *modularization,* allowing the flexible combination of modular elements into products.

Supply chain management

While processes occurring in other businesses cannot be controlled directly, they may be of vital importance for the success of a business. This challenge is addressed through the field of supply chain management:

"Supply chain management is the set of activities, decisions and responsibilities that coordinate suppliers, manufacturers and distributors so that products or services are produced and distributed efficiently, whilst minimizing costs and satisfying the requirements of the members of the supply chain."

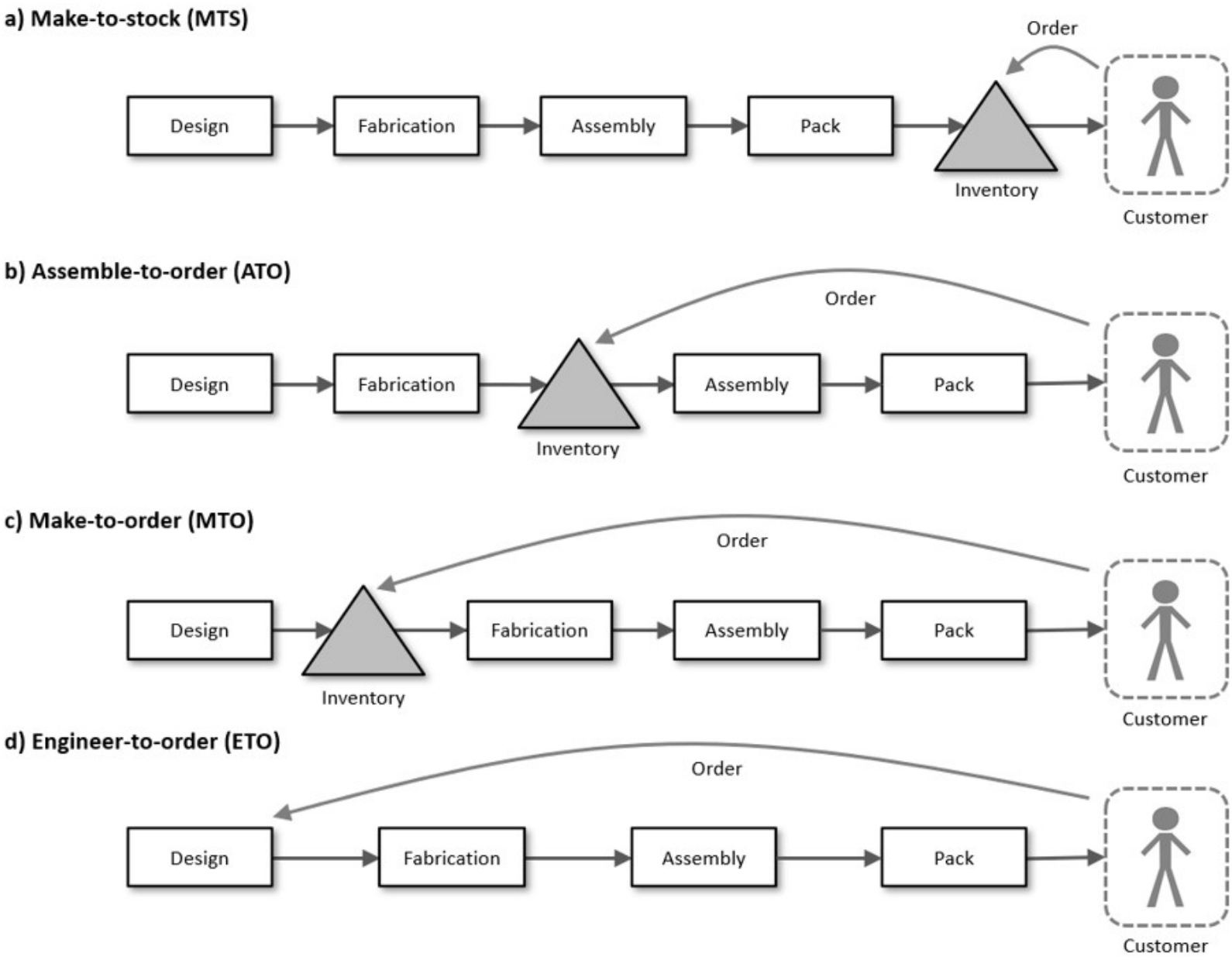
The three basic functions of supply chain management

- *Supply chain planning:*
  *I*nvolves the allocation, deployment and consumption of the resources available to a business to meet projected or actual demand in the long term

- *Supply chain scheduling:*
  Refers to the allocation of specific resources to activities across time periods in the short term

- *Supply chain control:*
  Ensures that plans and schedules are met or adhered to in the present. If a deviation is identified an action will be taken to mitigate further problems or risks

Classification of different supply chain structures



Demand forecasting

Generally, forecasting refers to the prediction or anticipation of future situations, events or conditions. This is an important activity in operations management.

- Forecasts are always uncertain so there can never be a guarantee that a forecast is correct
- Forecasting is necessary - without forecasts, businesses would have no choice but to react
- Outdated or otherwise low-quality forecasts are detrimental to the performance of operations

Levels of aggregation and time horizons

Forecasting comes in different levels of aggregation and with different time horizons.

- Forecasts that predict changes in aggregate variables, e.g. in product categories, are generally seen to be more accurate than forecasts for specific *stock keeping units* (*SKUs*)

- There are generally three different time horizons for demand forecasts:

Long term forecasts	Ranging from two to 20 or more years in the future.
Medium term forecasts	Periods from one to three years in the future
Short term forecasts	Present up to one year in the future

- These periods (intentionally) overlap and making accurate long-term forecasts is more difficult than making accurate short-term forecasts

Purposes of demand forecasting

1. Informing strategic decisions to enter or remain in a market

2. Determining the capacity needs of the business using long term forecasts

3. Adapting resource levels using medium term forecasts

4. Enabling cost effective, responsive operations

Qualitative demand forecasting

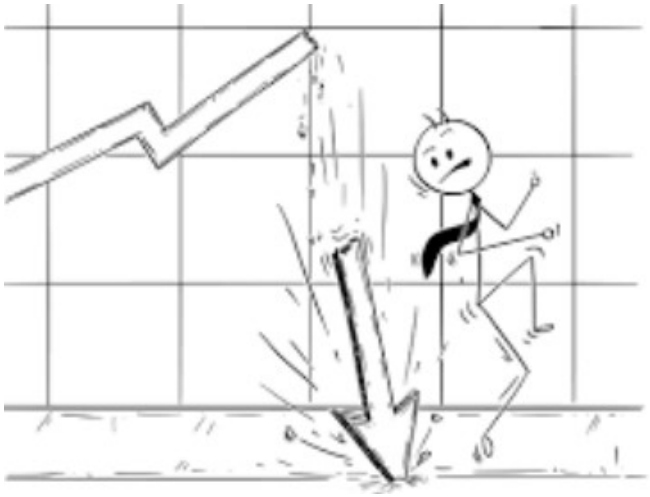
Qualitative forecasting refers to a group of techniques aiming to collect information, knowledge, experience and subjective opinions from decision makers, specialists and other experts.

- These are used to form a speculative description of the future
- Typically, qualitative forecasting anticipates long-term developments and changes
- Many techniques are available, common ones include the Delphi method, sales force survey and customer survey

Quantitative demand forecasting

Quantitative forecasting, uses numerical and statistical techniques to gather data and build models of relevant relationships. Within quantitative forecasting, two main approaches used:

- Time series modelling
- Causal forecasting



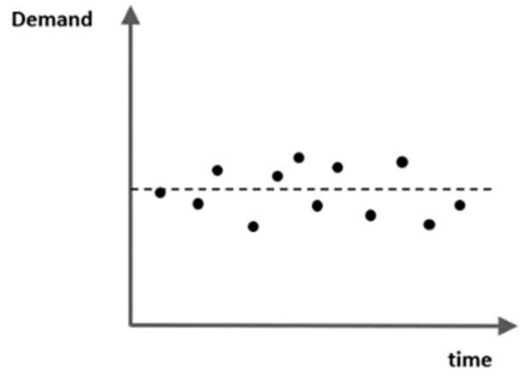
Time series modelling

Time series models are based on the assumption that the future behaviour of the subject under investigation is in some way shaped by its past behaviour:

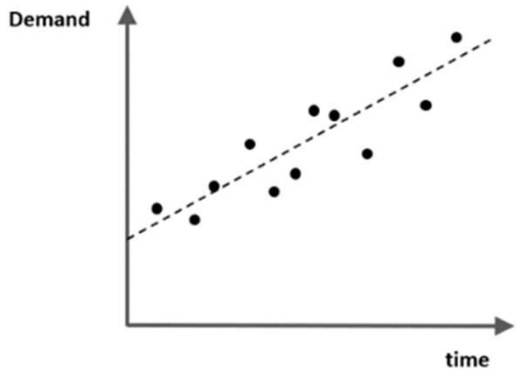
- Forming its own discipline within statistics and economics, time series modelling investigates variables that change over time
- The existence of trends in unrelated variables leads to false insights if incorrect statistical methods are applied
- This makes time series modelling a non-trivial and highly technical activity
- In operations management, demand forecasters often try to decompose complex behaviour of variables over time

Decomposition of behaviour in demand over time

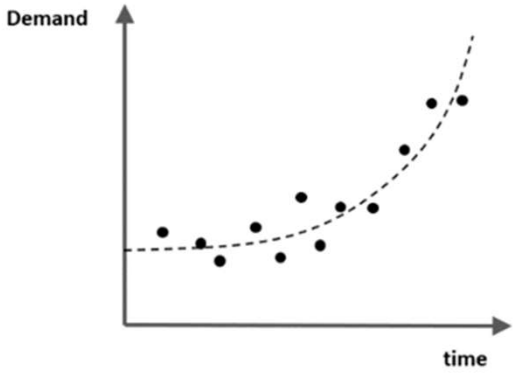
a) Constant with random variation



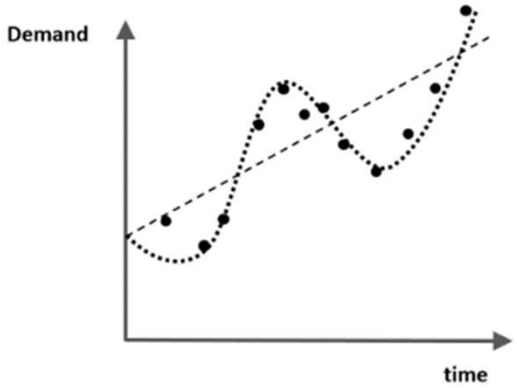
b) Random variation around a trend



c) Nonlinear trend



d) Seasonality and trend



- Trendlines of different types can be fitted to historical demand data using many software packages
- Moving averages are also often used to identify underlying patterns….

Causal forecasting

Similar to time series modelling but uses variables that do not change over time.

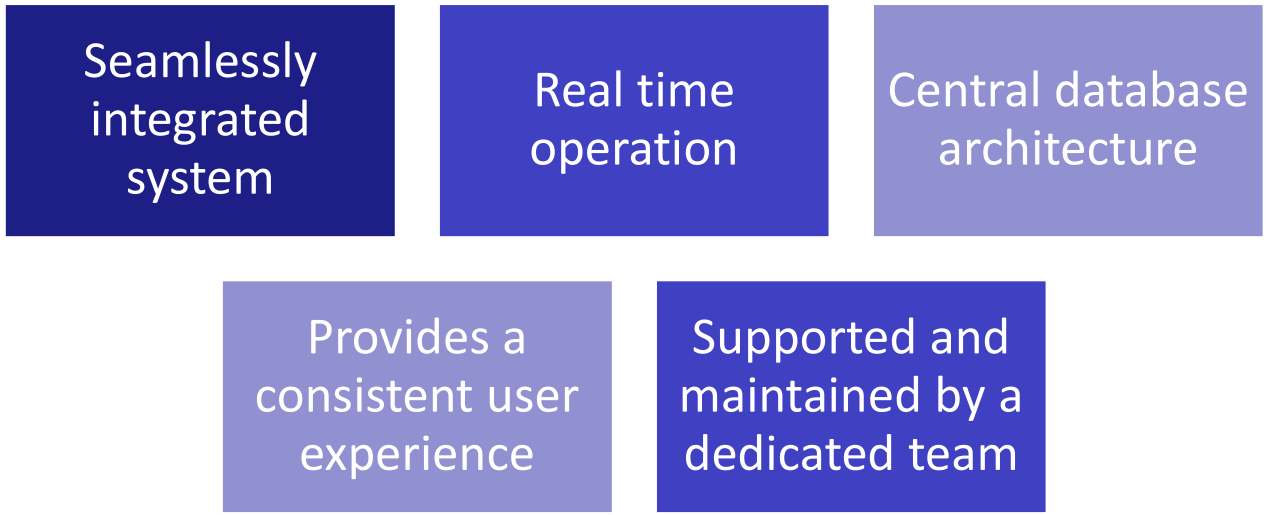
- This makes the statistical approaches used in causal modelling less complex and permits the use of relatively simple regression methods in what is known as *cross-sectional* statistical studies

- This form of forecasting aims to statistically infer causal relationships between a dependent variable and a cross-section of independent variables, which can then be used to predict the change in the dependent variable

Enterprise resource planning (ERP) systems

One of the most important developments of the recent past in operations management is the emergence of enterprise resource planning (ERP) systems:

- ERP systems provide functions for the planning, scheduling, operation and control of the operations in a business
- Typically, an ERP system has the following characteristics:



An overview of ERP functions

Function	Description
Sales administration	Functions allowing placement if orders, scheduling of orders, coordination of shipping and logistics and invoicing of customers.
Customer relationship management	Functions that are designed to manage the relationships with customers and to extract information from these.
Business Intelligence	Methods and technologies used analyze business information to support decisions by managers.
e-Commerce	Systems for the facilitation of transactions using online services or over digital networks.
Procurement	Administration of the acquisition of goods, services or information from outside sources and the associated inbound logistics.
Manufacturing resource planning and product lifecycle management	Running the operations system within the business as introduced in this lecture and managing the product life-cycle (PLM).
Distribution and outbound logistics	Control of warehousing, movement of goods and logistics.
Accounting	Feeding into and extraction of information from the accounting function in the business, ensuring compliance with regulations. An important function in this is running the general ledger of the accounting system.
Enterprise asset management	Management of resources, including equipment and infrastructure, controlled by the business with the objective of minimizing life cycle costs.
Supporting human resource management	Scheduling staff and supporting the human resources management function of the business.
Corporate performance and governance	Providing insight into the performance of the business for senior managers.