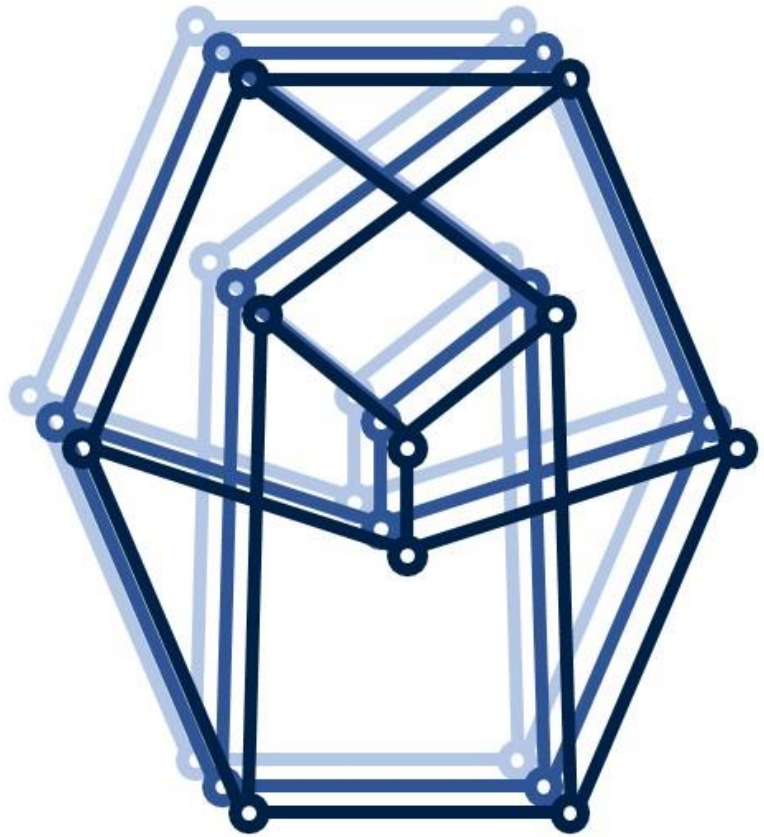

MPiE

Management Practice

1. Introduction

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MPiE

15/10/2020

Welcome

natural interaction lab
The University of Oxford

OXFORD HEALTHTECH LABS

Interested in the linking engineering and management

Course

Aim of this course:

Learn management approaches to improve the practice of engineering

Final assessment (0.5 Examination Units):

C27 - A 1.5 hrs written exam, which relates to the coursework that you will complete as part of MPiE.

B2E2 - A 3 hrs written exam, of which 1.5 hrs relates to the coursework that you will complete as part of MPiE – EEM selection.

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Understand the organisation and structure of the course
- Understand the value of engineering management practice
- Can apply different brain storming techniques

Literature for this session:

- Bloom, Nicholas, et al. "Does management matter? Evidence from India." *The Quarterly Journal of Economics* 128.1 (2013): 1-51.

Course

- The literature and lectures are complementary, so please read and attend/view to successfully pass your exam.
- There are active elements that require you to complete. Please do.
- This course is ideally to be viewed from a systems engineering perspective.
- Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation.
- We will look at management, with an emphasis on managing the design, development and engineering of systems.

Source: The International Council on Systems Engineering (INCOSE)

Engineering management introduction

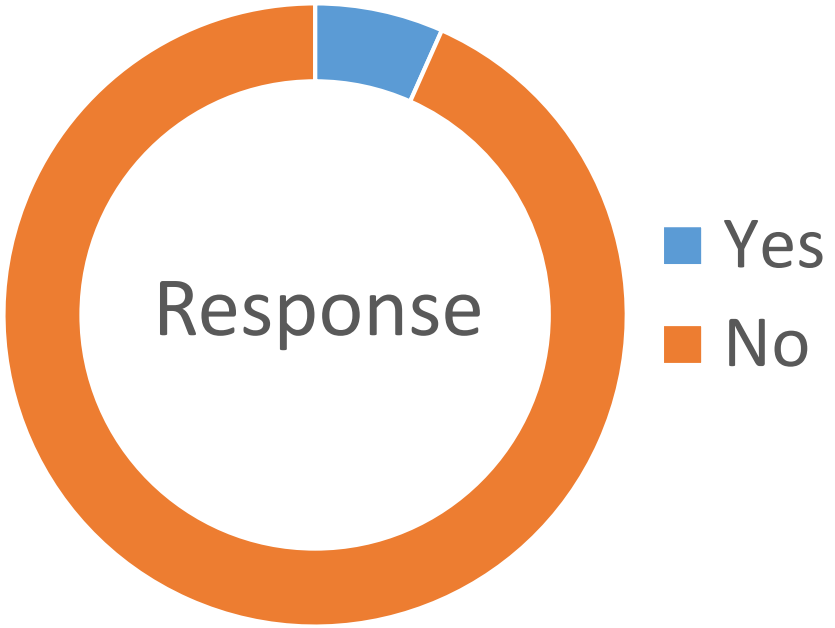
How many of you have led/managed a group of individuals (volunteer work / societies/ etc.)?

How many of you received any training in leadership and management skills?

A small poll

- Across a range of companies the following question was asked to engineering managers:

“Before becoming a manager did you participate in any formal management training?”



Source: by Former Twitter Director of Engineering - David Loftesness

Mind the gap

- One is often surprised that the skills and methods required to be successful as an single contributor do not map directly on success as a manager.
- There is a gap in skills and competencies required for this.

Source: https://hbr.org/2007/01/becoming-the-boss

Definition of management

- “The process of dealing with or controlling things or people.”

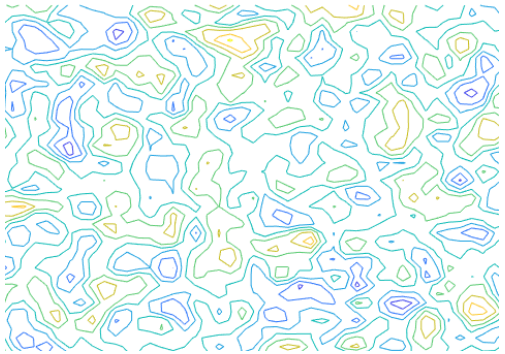
- Management is concerned with the effective use and coordination of materials and labour within organisations in the pursuit of the organisation’s **defined objectives**. It considers the interrelationship and interactions between distinct parts of an organisation, and between the organisation and its environment.

Source: Oxford Dictionaries; Economics and Management University of Oxford

Management in engineering

Engineering Management professionals are engineers with the advanced knowledge and skills both technical and managerial in managing engineering activities and organizations.

How to become one that can effectively take on an ever changing landscape? And if the landscape is dynamic is there indeed any value in management?



Value of management

- There is the belief **that competition will drive badly managed firms out** of the market. As a result any residual variations in management practices will reflect firms' optimal responses to differing market conditions.

- For example, firms in low-income countries may not adopt quality control systems because wages are so low that repairing defects is cheap. Hence, their management practices are not "bad", but the **optimal response** to low wages.

- Management itself can be hard to measure, so it easy to see why such a statement would seem plausible.

- The effect of management is however measurable using specific (commercial) outcome measures.

Source: http://www.nber.org/papers/w16658

Value of management

- More literature is now measuring different management practices and large variations across entities are found and there seems to be a strong association between the practices and productivity, as well as profitability.

- A range of management approaches are applied throughout the industries.

Source: Lucas (1978, p. 511); MacDuffie (1995), Ichniowski, Shaw and Prennushi (1998), Cappelli and Neumark (2001) and Bloom and Van Reenen (2007).

Snapshot of management practices

	Association of project Management (APM)	Project Management Institute (PMI)	PRINCE2
Feature	Pragmatic approach to project management based on published body of knowledge	Based on detailed body of knowledge	Detailed step-by-step process
Sector	Across sectors (UK)	Applied globally (US focus)	Often seen in IT and product focused sectors (often used in public sector in UK)

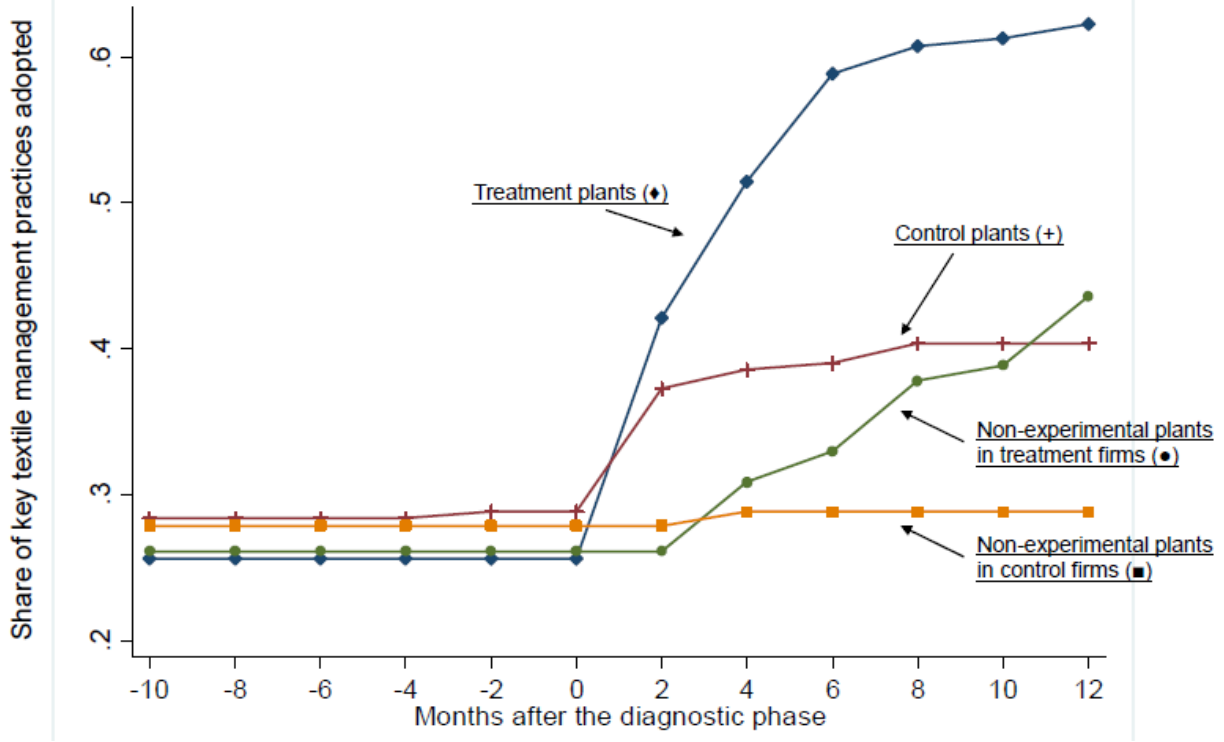
Source: 2020projectmanagement

An experiment

A **management field experiment** was conducted in some large Indian textile firms.

The researchers provided free **consulting on modern management practices** to a randomly chosen set of treatment plants and compared their performance to the control plants.

Figure 2: The adoption of key textile management practices over time



Source: http://www.nber.org/papers/w16658

An experiment – management practices

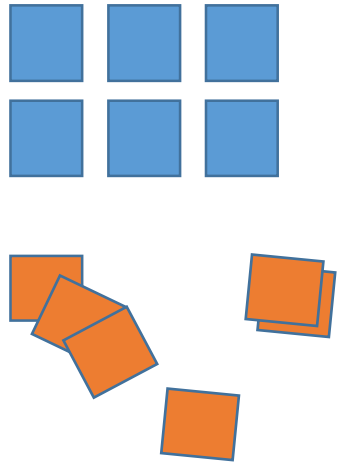
Factory Operations: Regular maintenance of machines and recording the reasons for breakdowns to learn from failures. Keeping the factory floor tidy to reduce accidents and ease the movement of materials

Quality control: Recording quality defects by type, analyzing these records daily, and formalizing procedures to address defects to prevent them recurring.

Inventory: Recording yarn stocks on a daily basis, with optimal inventory levels defined and stock monitored against these. Yarn sorted, labelled and stored in the warehouse by type and color, and this information logged onto a computer.

Human-resource management: Performance-based incentive system for workers and managers. Job descriptions defined for all workers and managers.

Sales and order management: Tracking production on an order-wise basis to prioritize customer orders by delivery deadline. Using design-wise efficiency analysis so pricing can be based on design (rather than average) production costs.



Source: http://www.nber.org/papers/w16658;

An experiment – outcome

Results of integrating modern management practice:

1. It **raised average productivity** by 11% through improved quality and efficiency and reduced inventory.

Other effects noted:

1. It **increased decentralization of decision** making, as better information flow enabled owners to delegate more decisions to middle managers.
2. It **increased the use of computers**, necessitated by the data collection and analysis involved in modern management.

Source: http://www.nber.org/papers/w16658

Moving to the other end of the scale

How is engineering management affecting start-ups and early SMEs?

The start-up community is actively looking for engineering managers, as there is a growing need of technical management in companies.

Within a start-up the absence of structure might hinder important activities, such as sharing knowledge and team coordination, especially when the company grows.

Providing structure and clarity is important from a management point of view.

Source: DOI: 10.1109/MS.2014.129

Start-up

We define a start-up using the criteria: “new”, “active” and “independent”. This can be captured as:

“which did not exist before during a given time period (new),which starts hiring at least one paid employee during the given time period (active),3 and which is neither a subsidiary nor a branch of an existing firm (independent).”

(i) Start-ups fail at an early stages and roughly only 1/3 turn into companies, showcasing a high rate of failure
(ii) The failure is due to a range of factors, such as such as limited finance, lack of understanding the need and team management problems to name just a few.

Source: Giardino et al 2014; Vesper, 1990; Núñez, 2007; Michael I. Luger and Jun Koo, 2003

Success factor start-ups

Several studies have documented that the success in small software companies is particularly dependent on having better technical and management practices in (software) processes.

It has been shown that better practices can mitigate some of the most common occurring problems.

Across different segments and entities the effect of good management practice has been shown.

Source: X. Larrucea et al., “Software Process Improvement in Very Small Organizations,” 2016; Crowne, “Why Software Product Startups Fail and What to Do about It”, 2002

Managing the development process

Process management represents the engineering activities used to **manage product development** in start-ups. Because the flexibility to accommodate frequent changes is essential in the start-up context, agile or lean methods (we will get back to these later in the course).

Several techniques can be applied by the team to be flexible in terms of organisation and idea generation.

We will focus on the often used technique of **brainstorming** to address a problem or question.

Source: Giardino et al 2014

Brainstorming - background

Brainstorming is a technique that engineers use to generate, express and organise ideas.

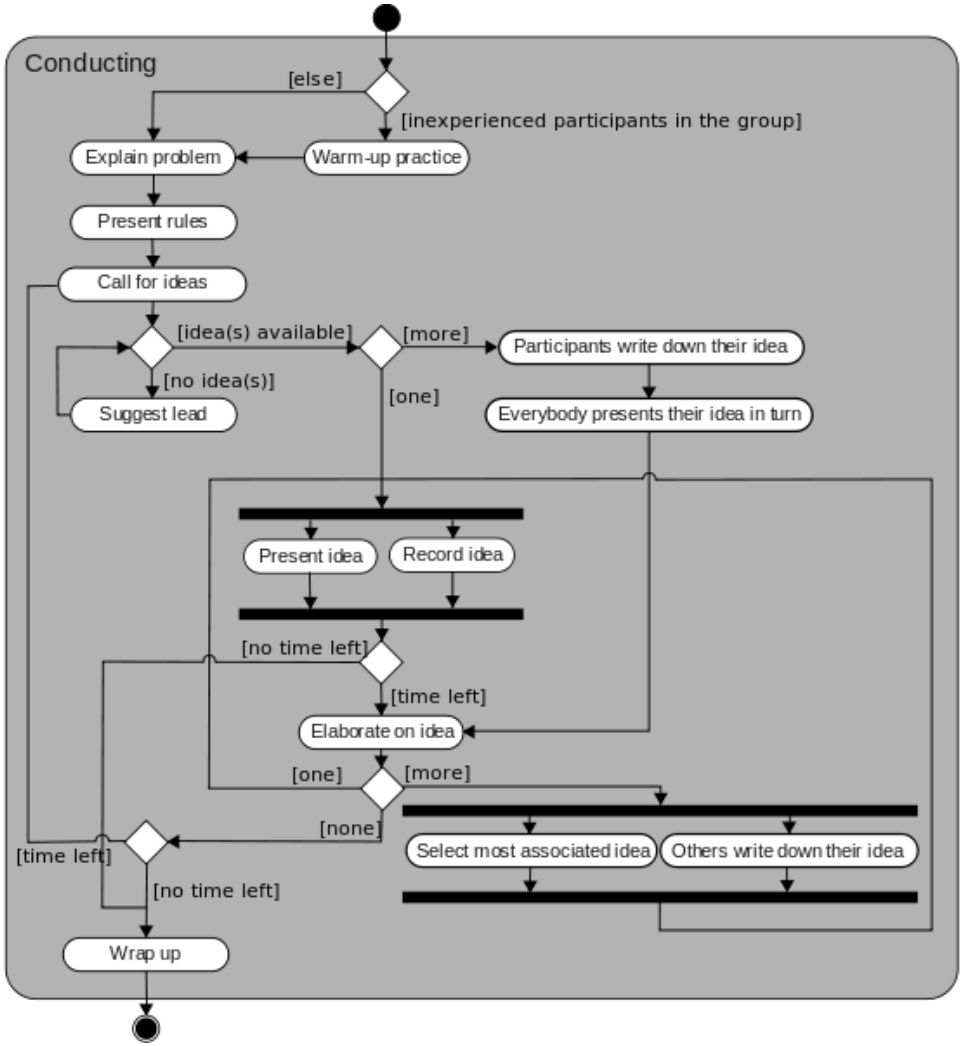
The advertising executive, Alex Faickney Osborn (1888 – 1966), is seen as the person who defined the brainstorming technique.

The rules for brainstorming emphases **quantity** and the prohibition of **evaluation**. These rules were designed to increase the raw number of ideas without particular regard for quality.

Group brainstorming is usually considered a task of divergent thinking.

Source: McGlynn et al 2014

Brainstorming



Source: Penn State Uni (iStudy)

Brainstorm in teams

- Form a team of 2-4
- Use Teams to meet-up
- Pick a colour

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Brainstorm in teams

- Brainstorm alternative products that could be made with a piece of metal string (**grey**) or wooden stick (**brown**)
- Mention the idea to the team and write down the idea in the chat function (5 mins)
- Discuss and sort the ideas (cluster, pipeline, etc) - (5 mins).

Brainstorming individually

- Brainstorm alternative products that could be made with the opposite object that you just selected as a team, which was a **piece of string** or **wooden stick**

- Write down your ideas in the team chat (keep to **5 mins**)

- Discus and sort the ideas (cluster, pipeline, etc) and take a picture (5 mins).

Recap

- Which technique did you prefer?

- How many ideas (*n*) did each team or summed individuals get?

See if $n_{team}=n_{individuals}$

Overview

- “Early in creative acts it’s **important to diverge**, that is, to think about what you are doing in as many ways as possible. Later, you want to converge on a small number of paths to follow in more detail.”

- “Many techniques use a structure like this. For example, in the 6-3-5 method, six people sit around a table and write down three ideas. They pass their stack of ideas to the person on their right, who builds on them. This passing is done five times, until everyone has had the chance to build on each of the ideas. Afterward, the group can get together to evaluate the ideas generated.”

- “There are many variations of techniques like this. What they have in common is that they allow individual work during divergent phases of creativity and group work during convergent phases.”

Source: *Art Markman, Harvard Business Review, 2017*

Group brain storming

- Literature has shown that groups produced **fewer ideas** than an equivalent number of individuals working alone (nominal groups).

- A meta-analysis, even found that **interacting groups usually produced poorer ideas in terms of quality** then nominal groups.

- Yet, group brainstorming was **perceived as more effective than individual brainstorming** by both interacting and nominal group members, a finding that extends the illusion of group productivity in brainstorming to tasks of convergent thinking. This might explain the popularity of it throughout industry.

- The effect between standard groups and nominal **groups reduces when brainstorming takes place later in the task** where there is a large amount of accumulated evidence to consider.

- Interestingly, **electronic brainstorming has been found to match that of nominal groups**.

Source: McGlynn et al 2014; Mullen et al. (1991); Gallupe et al (1991)

Electronic brainstorming

Use google docs/teams/e-mail/etc. to brainstorm on a “product” you want to develop and state for which year group.

1. (Anonymously) post you ideas (till 16th at 5pm)
2. Categorise ideas by keyword and eliminate redundant ideas (till 17th at 5pm)
3. Assess quality and rank them (till 18th at 5pm)
4. Select the best one (till 19th at 5pm)

Source: R. Brent Gallupe and William H. Cooper (1993)

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Questions?

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Management Practice

2. Operations and systems

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Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to define operation management
- Able to relate systems to management
- Able to complete Porter’s value chain
- Able to draw a simple supply graph

Operation management

Management was shown to **add value**, but we can further split the concept of management and explore the different aspects.

Operations management **optimises planning, organisation and supervision in production and manufacturing**.

It is **delivery-focused**, ensuring that an organization successfully turns inputs to outputs in an effective manner.

Source: MIT Sloan School of Management

Operation management definition

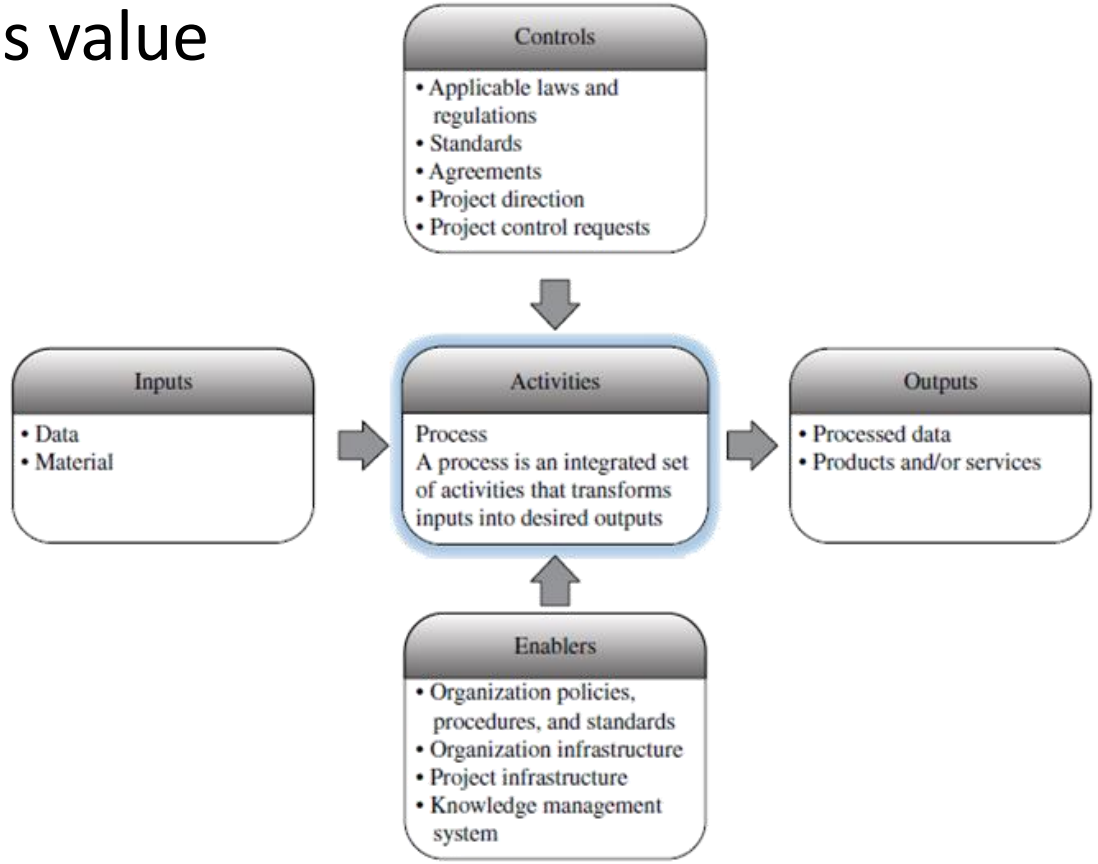
- This is the management of **processes that create value** for a company and its customers. These processes transform inputs - such as materials, energy, services and people - into goods and services (outputs).

Core functional activities	*Internet service provider (ISP)*	*Fast food chain*	*International aid charity*	*Furniture manufacturer*
Marketing and sales	Promote services to users and get registrations Sell advertising space	Advertise on TV Devise promotional materials	Develop funding contracts Mail out appeals for donations	Advertise in magazines Determine pricing policy Sell to stores
Product/service development	Devise new services and commission new information content	Design hamburgers, pizzas, etc. Design décor for restaurants	Develop new appeals campaigns Design new assistance programmes	Design new furniture Coordinate with fashionable colours
Operations	Maintain hardware, software and content Implement new links and services	Make burgers, pizzas etc. Serve customers Clear away Maintain equipment	Give service to the beneficiaries of the charity	Make components Assemble furniture

Source: FT.com; Slack, Nigel, Stuart Chambers, and Robert Johnston. *Operations management*. Pearson education, 2010.

The input–process–output (IPO) diagram

Process that creates value



Source: INCOSE Systems Engineering Handbook, version 3 .

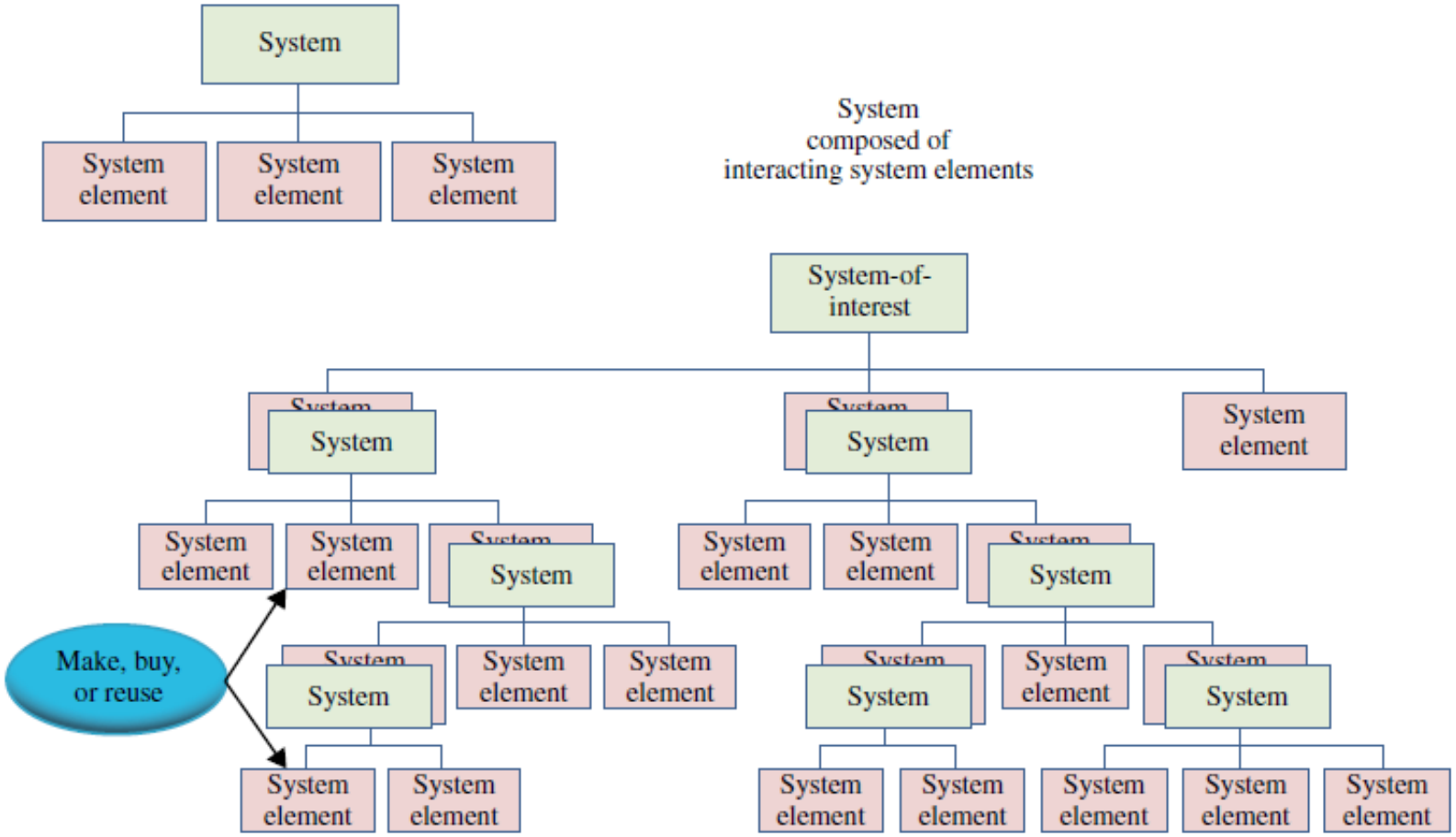
Systems

- Systems are **man-made, created and utilized** to provide products or services in defined environments for the benefit of users and other stakeholders.

- An attribute of a system (or system element) is an **observable characteristic or property of the system** (or system element).

Source: INCOSE Systems Engineering Handbook, version 3 .

Hierarchy within a system



Source: INCOSE Systems Engineering Handbook, version 3 .

System of systems (SoS)

A system of systems is a system of interest whose elements are **managerially and/or operationally independent systems**.

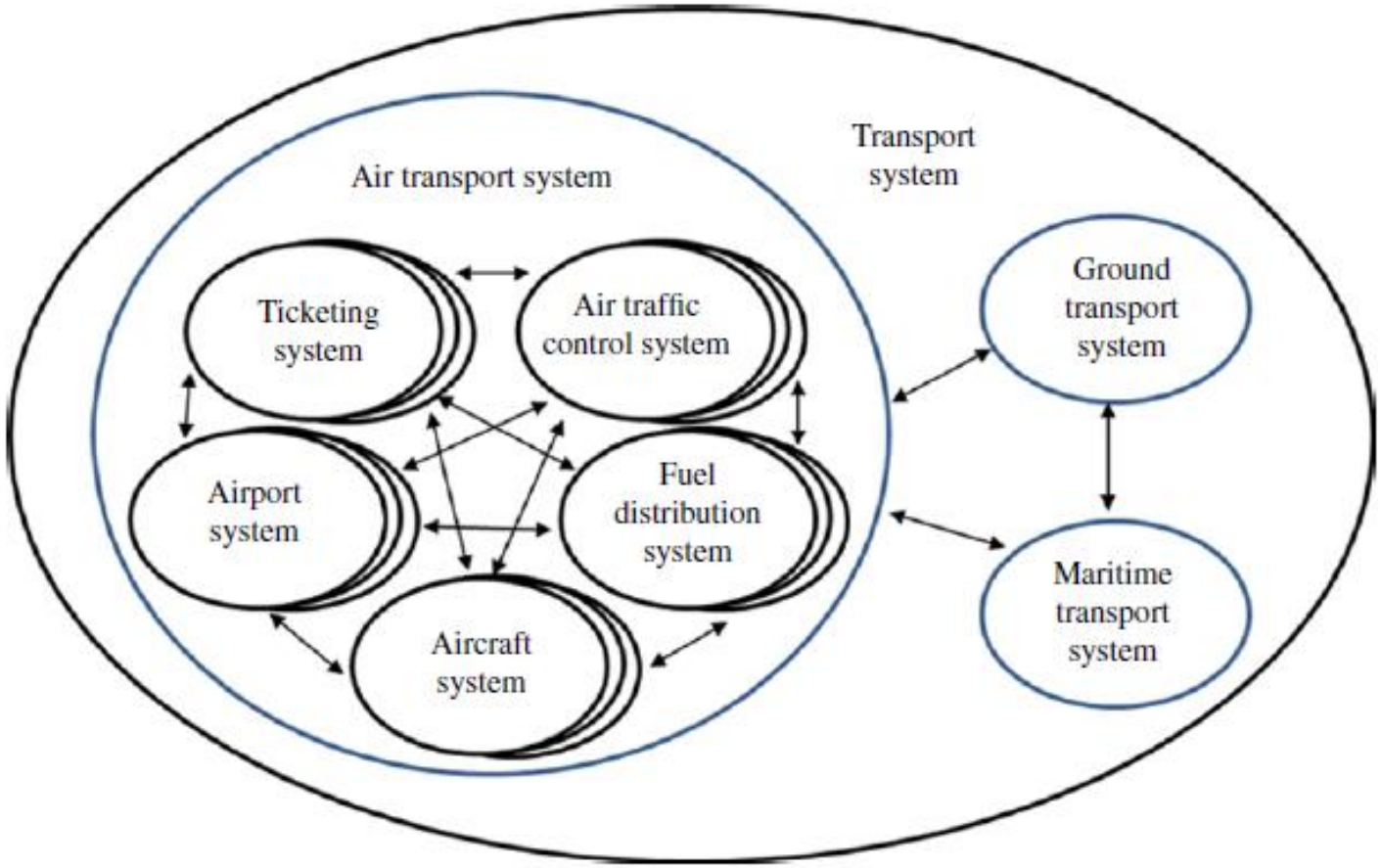
These interoperating and/or integrated collections of constituent systems usually produce results unachievable by the individual systems alone.

The following (Maier's) characteristics can be useful when deciding if a particular System of interest can better be understood as an SoS :

- Operational independence of constituent systems
- Managerial independence of constituent systems
- Geographical distribution
- Emergent behaviour
- Evolutionary development processes

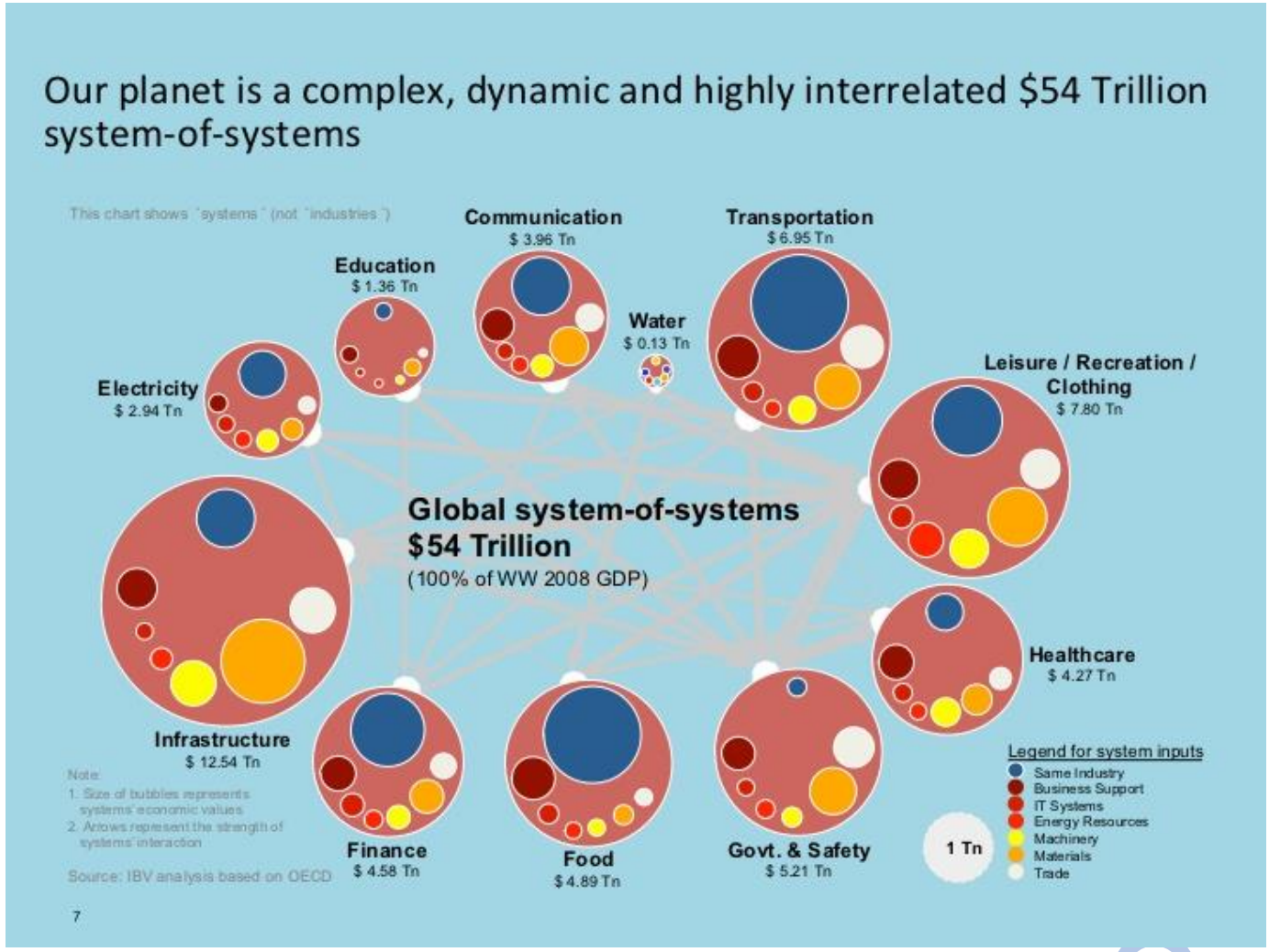
Source: Maier, 1998

System of systems example



Source: INCOSE Systems Engineering Handbook, version 3 .

World as system of systems



System of systems

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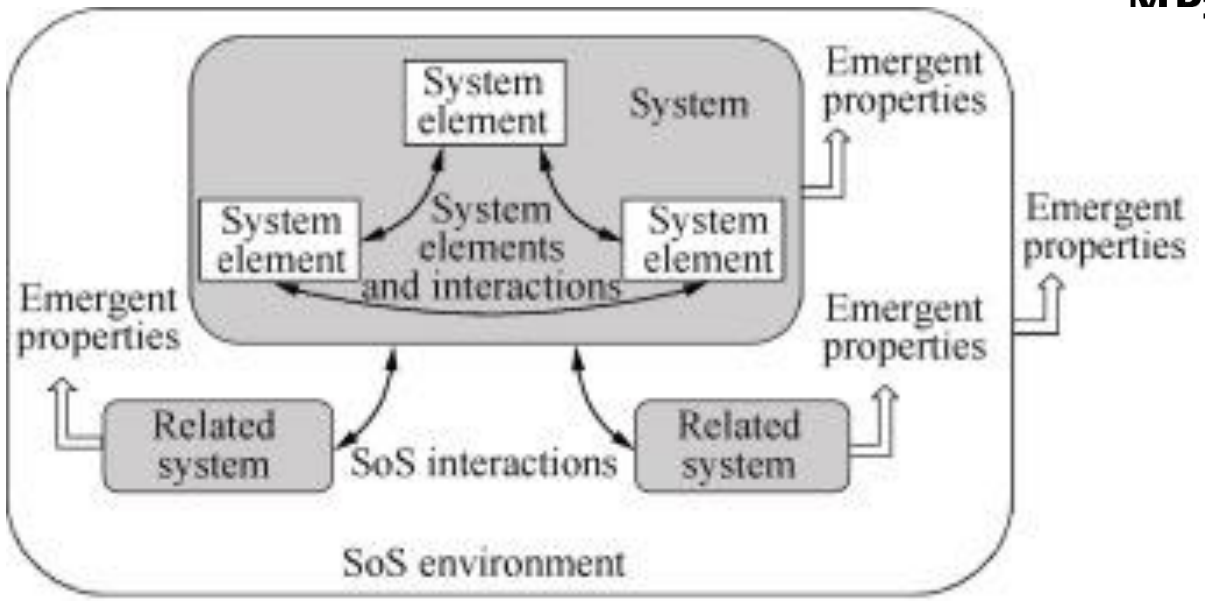


Draw a system of systems example

Source: //doi.org/10.1016/j.cja.2016.01.002

System of systems (SoS)

- The SoS usually exhibits **complex behaviours**, often created by the existence of the Maier's characteristics.
- The complex system can't just be understood by its parts alone, because the **emergent properties** that we really care about disappear when we examine the parts in isolation.
- A fundamentally different approach is required to understand the whole in context through **iterative exploration** and adaptation.
- Linear, procedural methods for sorting through complicatedness ("systematic activity") and holistic, non-linear, iterative methods for harnessing complexity ("systemic" or systems thinking and analysis—always required when dealing with SoS).

Source: INCOSE Systems Engineering Handbook, version 3 .

Operational management

- In this sense an operation is a **system of functions that transforms** inputs into outputs of greater “value”.
- The process takes place along a **value chain**.
- The value chain can be regarded as a **complete transformation model overlaid by the necessary support functions**.
- Functions that do not add value should be **eliminated**.
- Operations management consist of the design, operation an improvement of this system in this context.

Porter’s value chain

Value chain is a tool designed to systematically divide a company into its “**strategically relevant**” activities, analyse their behaviour and interaction, and determine their importance in the implementation of business strategies.

In Porter’s model the value chain activities can be divided in two categories:

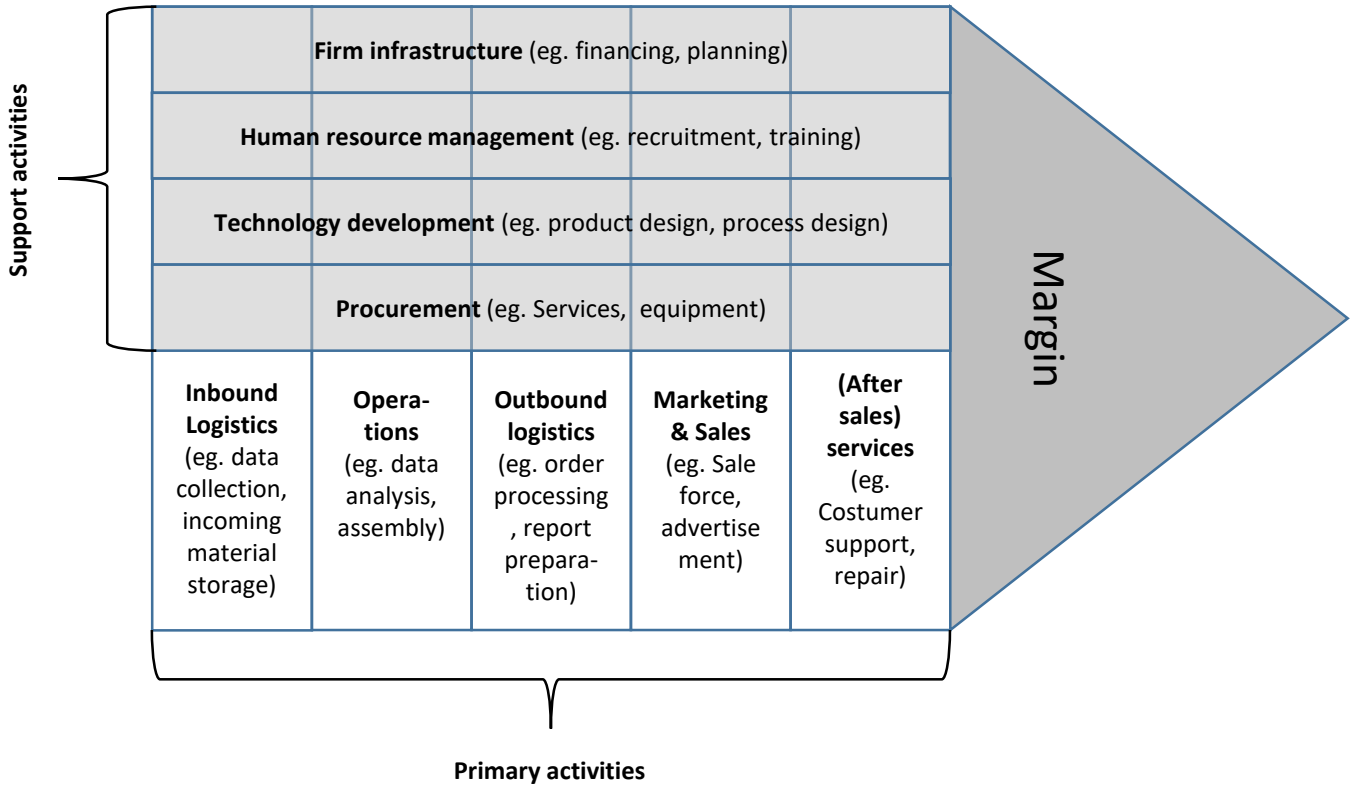
1. Primary activities
2. Support activities

The **primary activities** are those related to the **physical creation and delivery** of the product to the customer.

The **support activities** are involved in the procurement and management of the resources needed by the primary activities to operate.

Source: Porter, 1985; Edgar Arias, Sustainable Innovation Management

Porter's value chain

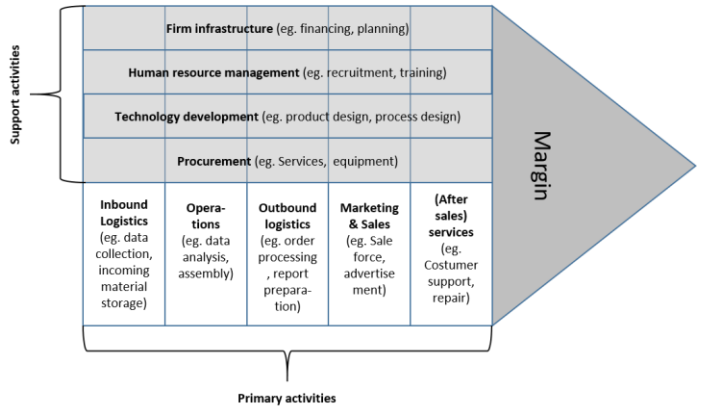


Source: Porter, 1985; Edgar Arias, Sustainable Innovation Management

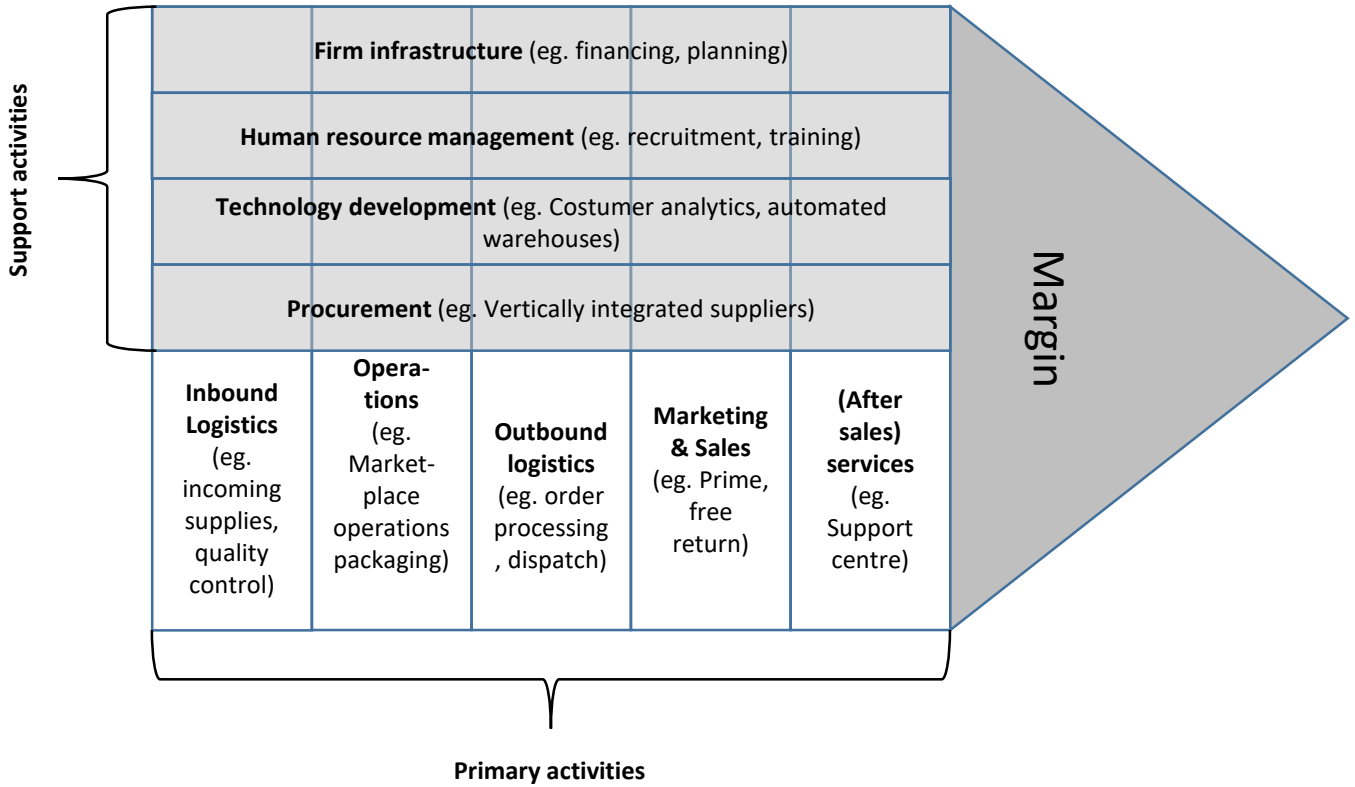
Value chain in application

- What would be the value chain for Amazon (marketplace)?

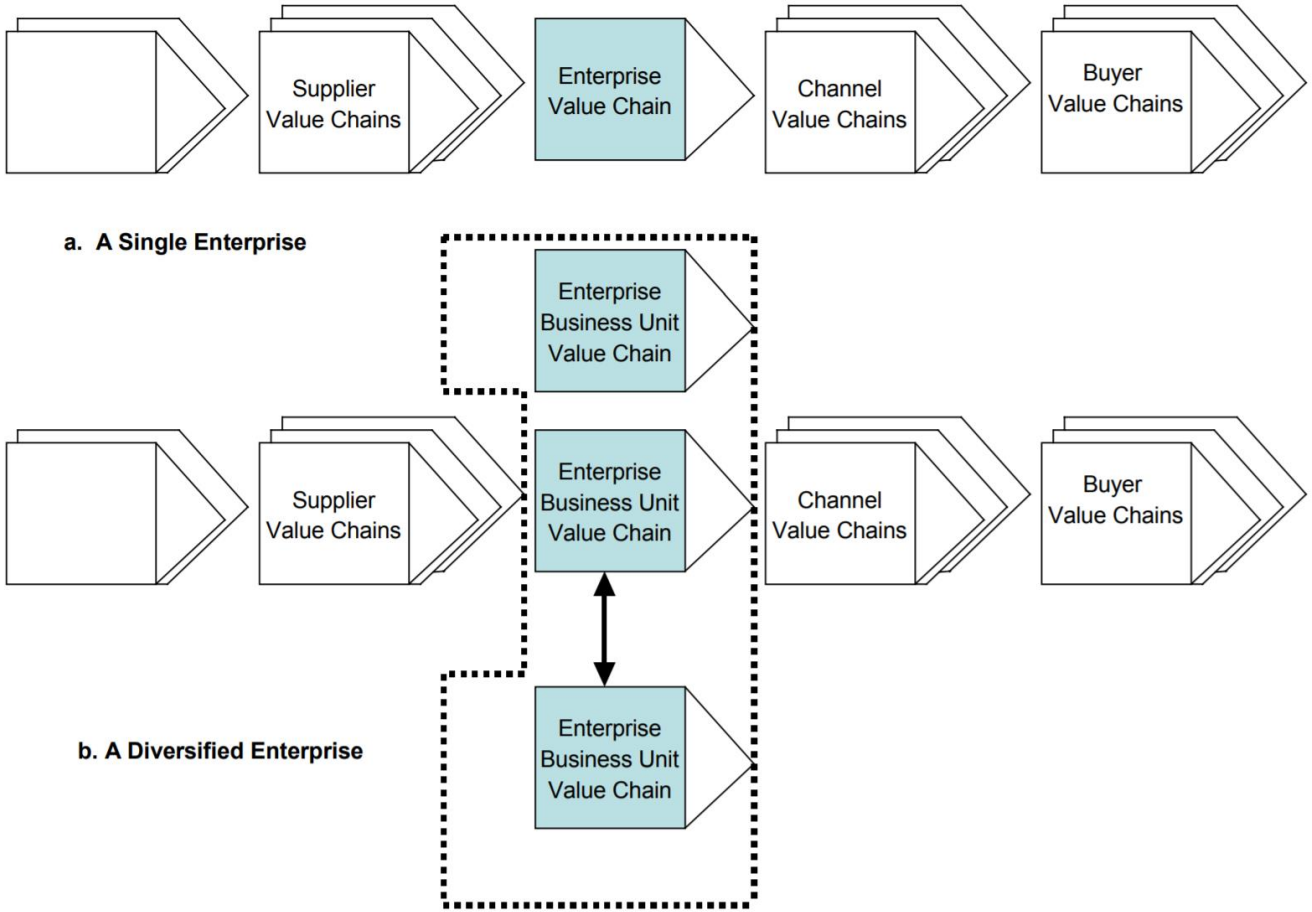
- Discuss and write down your value chain (5 mins).



Value chain


Support activities
Firm infrastructure (eg. financing, planning)
Human resource management (eg. recruitment, training)
Technology development (eg. Costumer analytics, automated warehouses)
Procurement (eg. Vertically integrated suppliers)
Inbound Logistics (eg. incoming supplies, quality control)
Opera-tions (eg. Market-place operations packaging)
Outbound logistics (eg. order processing , dispatch)
Marketing & Sales (eg. Prime, free return)
(After sales) services (eg. Support centre)
Margin
Primary activities

Value chain as a network



Source: Nyamekye, K. Axiomatic Design Approach for Designing Re-configurable C4isr Systems (2007)

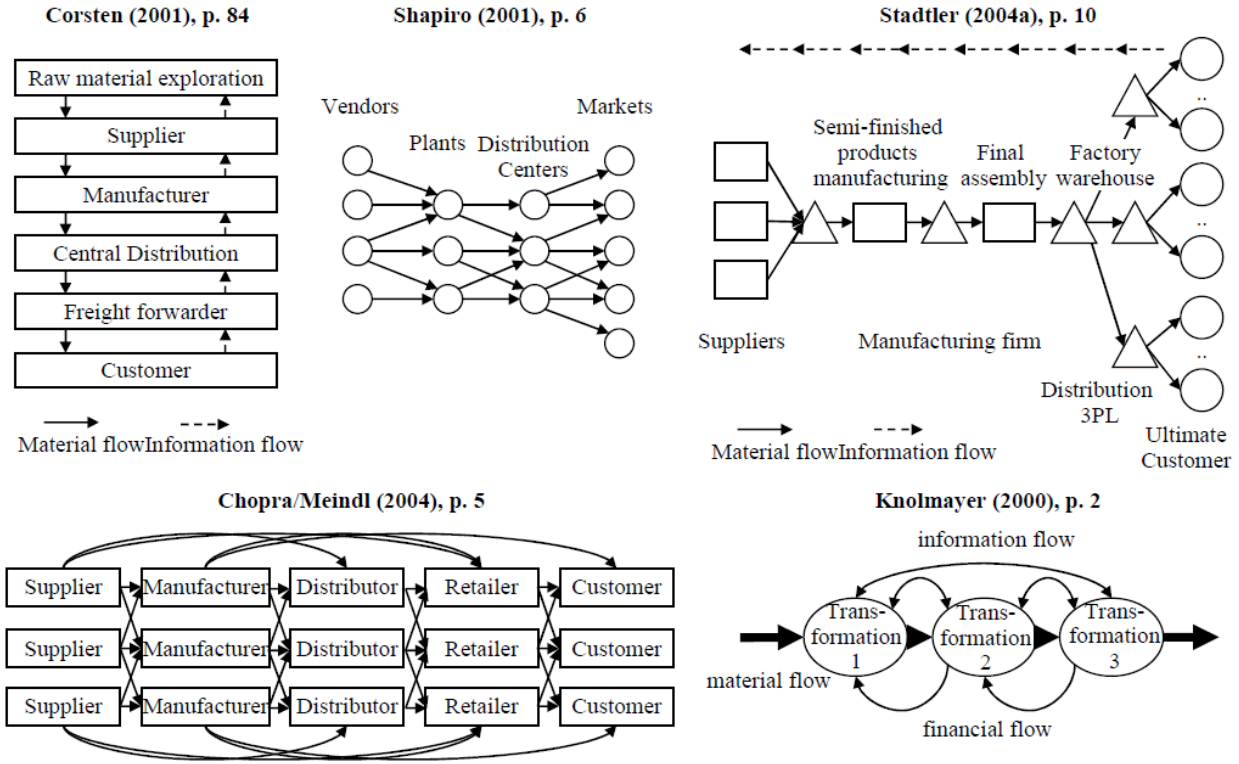
Value chain to supply chain

- Porter's value chain was a basis for the development of the **supply chain**.
- Compared to the company-internal focus of Porter's value chain, the supply chain extends the scope towards **intra-company** material and information flows from raw materials to the end consumer reflected in the definition of Christopher (1992):

A supply chain is a network of organizations that are involved through upstream and downstream linkages in different processes and activities that produces value in the form of products and services in the hand of the ultimate consumer.

Source: Kannegiesser (2008)

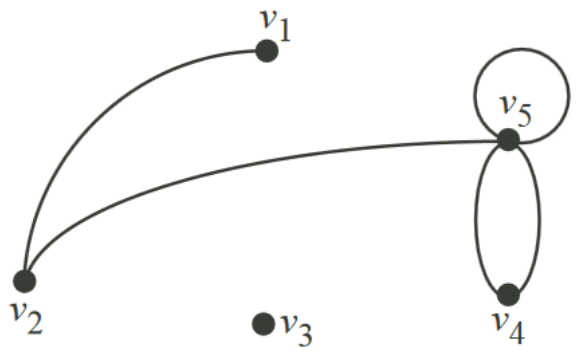
Capturing the supply chain



Source: Kannegiesser (2008)

Supply chain as graph

A graph is formed by vertices and edges connecting the vertices.



Better is to state a graph is a pair of sets (*V, E*), where *V* is the set of vertices and *E* is the set of edges.

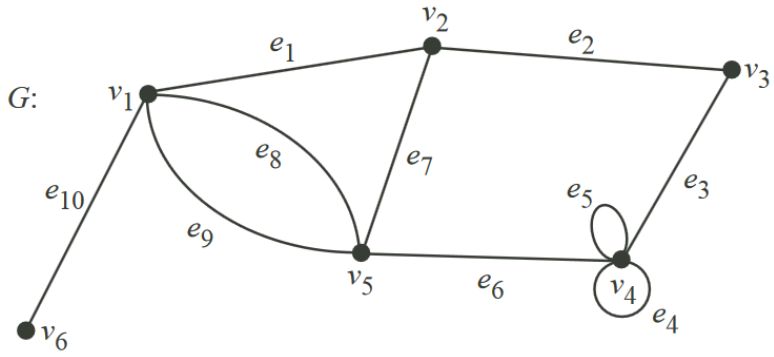
$$V = \{v_1, \dots, v_5\}$$

$$E = \{(v_1, v_2), (v_2, v_5), (v_5, v_5), (v_4, v_5), (v_5, v_4), \} = \{e_1, \dots, e_5\}$$

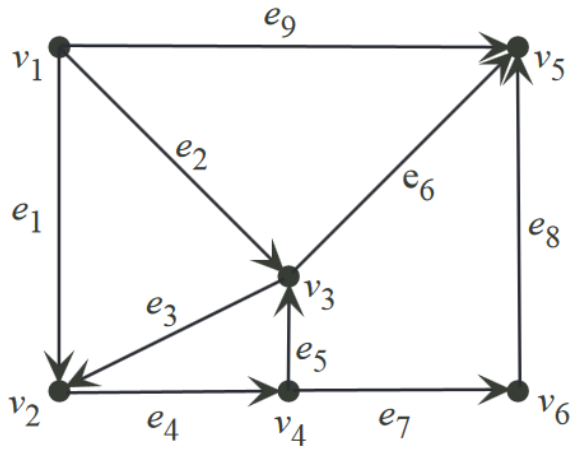
Source: Kannegiesser (2008)

Walk and directed graph

A walk in the graph *G = (V, E)* is a finite sequence which consists of alternating vertices and edges of *G.*



A directed graph can be used to capture characteristics of the supply chain



The two vertices *u* and *v* are end vertices of the edge (*u, v*), so an edge (*v, v*) is a loop.

Closeness centrality

- The value of representing supply chains as graphs, or networks, rather than as flat structures and relational databases has benefits for analysis.
- Interpreting supply chains as graphs produces new opportunities to investigate **structural characteristics and transitive links of complex relations.**
- **Closeness centrality** can be used to evaluate the flow of materials through a supply chains.
- Product platforms with **smaller** distances are connected to shorter supply chains and are thus have a **reduced risk** for encountering distortion in physical and information flows.

Source: Carstens et al (2017); //doi.org/10.1016/j.susmat.2016.10.002

Closeness centrality

Closeness centrality (*C*) measures a vertex's (or nodes's) centrality in a graph. It is the total vertices count *N* (minus one for the vertex itself) divided by the sum of the length of the shortest paths between the vertex and all other vertices in the graph or distance *d*(*y, x*), as

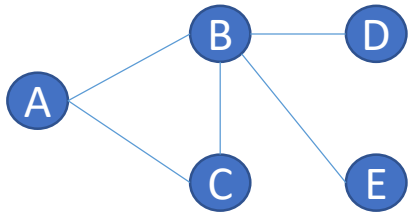
$$C(x) = \frac{N - 1}{\sum_y d(x, y)}$$

with $x \neq y$ and *d(i,j)* being the shortest path between vertices *i* and *j*

Source: Carstens et al (2017)

Closeness centrality (normalised)

$N = 5$



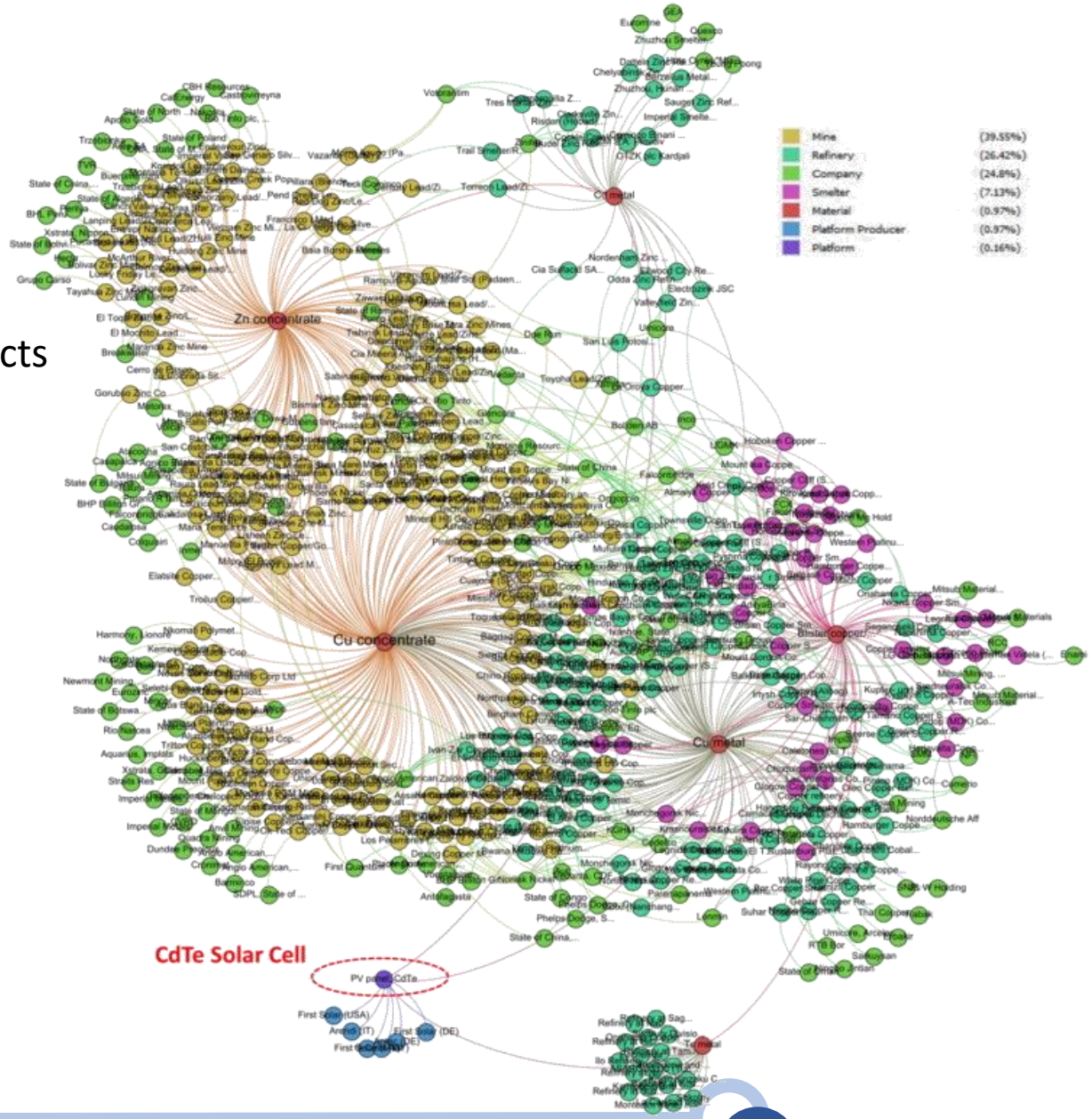
$V = \{v_1, \dots, v_5\} = \{A, \dots, D\}$

	A	B	C	D	E	$\sum_{k-1}^{N} d(v_i, v_k)$	$C(v_i) = \frac{N-1}{\sum_{k-1}^{N} d(v_i, vk)}$
A	0	1	1	2	2	6	.67
B	1	0	1	1	1	4	1
C	1	1	0	2	2	6	.67
D	2	1	2	0	2	7	.57
E	2	1	2	2	0	7	.57

Supply chain graph

Relationships mapped between material and products

(i) cadmium telluride solar cell
(ii) a germanium solar cell
(iii) a turbine blade
(iv) a lead acid battery
(v) a hard drive (HD) magnet



Source: doi.org/10.1016/j.susmat.2016.10.002

Factors influencing supply chain

SUMMARY OF RISKS

Type of risk	Source
Supply Risks	Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes
Operational Risks	Breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology; changes in operating exposure
Demand Risks	New product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the Bullwhip Effect on demand distortion and amplification)
Security Risks	Information systems security; infrastructure security; freight breaches from terrorism, vandalism, crime, and sabotage
Macro Risks	Economic shifts in wage rates, interest rates, exchange rates, and prices
Policy Risks	Actions of national governments like quota restrictions or sanctions
Competitive Risks	Lack of history about competitor activities and moves
Resource Risks	Unanticipated resource requirements

Source: Manuj et al, Global supply chain risk management strategies, 2008

Risk in the extended supply chain

Source: Manuj et al, Global supply chain risk management strategies, 2008

Supply chain risk

- When a firm takes a traditional, cost minimization approach to supply chain strategy, it often increases its risk of failure or increases its overall cost.
- Traditional solutions remain optimal as long as nothing changes, but they are extremely fragile to exceptions, failure, or changes in cost.
- Vinod Singhal at Georgia Tech's DuPree College of Business found **that supply chain glitches negatively impacted stock prices** by nearly 20% and it was the biggest factor for stock prices.
- For example, the chance that materials don't arrive in time threatens to disrupt service or increase cost on a daily basis.

Source: Kilgore, 2004

Supply chain risk - mitigation

- Identify where a large proportion of operating activities are tied up in a single location, organization, or flow. A graph that includes all supply chain vertices from source to customer can help identify **centralised risk**.
- Filter out **high-contingency risks**.
- Estimate the **probability** of each risk materializing. Economic forecasters and industry watchdogs can be good sources for macro economic plans, interest or labour rates, and union negotiation issues
- Assess the **impact** associated with each risk.
- Evaluate the **cost** of spreading the risk.

Source: Kilgore, 2004

Next lecture

- We will go further with supply management in the next lecture.

MPiE

Questions?

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Management Practice

3. Supply

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MPiE

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to define logistics and supply chain
- Able to state factors that influence the supply chain
- Able to provide a mathematical model for queuing
- Able to apply a model of queuing on to a problem

Literature for this session:

- Wagner, Stephan M., and Nikrouz Neshat. "Assessing the vulnerability of supply chains using graph theory." *International Journal of Production Economics* 126.1 (2010): 121-129.
- Little, John DC, and Stephen C. Graves. "Little's law." *Building intuition*. Springer, Boston, MA, 2008. 81-100.

Intro

Supply chain

The sequence of activities that take a product from a raw material to a consumable good.

50-70% The percentage of a company's profits that can be eaten up by supply chain and logistics costs. [1]

Supplier

A person or group in the supply chain that provides the materials, goods, or services needed to create a product.

From 10 to 10,000 The number of suppliers in a supply chain can vary greatly. A major retailer may have thousands, while a small mom-and-pop shop could have just a few.

Distributor

Companies who deliver goods or services to places where they are stored or sold, like warehouses, stores, or directly to customers.

$4 Billion USD

Projected increase in revenues from digital music distribution from 2015 to 2020. In the era of digital supply chains, distributors deliver more than just physical goods.[5]

Supply chain management (SCM)

Oversight of the manufacturing, distribution, and transportation of a product from raw material to finished good.

$10 Billion USD

Loss in revenue caused by Typhoon Halong in 2014, which severely disrupted supply chains in Southeast Asia. Managing disruptions is a top priority for supply chain managers.[2]

Inventory

Materials, parts, or finished products that are stored until ready for use. Suppliers stock inventories of raw materials to send to buyers. Retailers keep inventories of ready-to-sell products on hand.

95% The accuracy level of retailers' inventory data when they use item-level tagging (such as RFID tags) to track their merchandise. Tagging helps retailers know precisely what they have and where it's located.[6]

Logistics

Logistics ensure that a product moves efficiently through the supply chain – making sure that everything is at the right place at the right time.

37 Cents USD Total logistics cost of delivering a $3.60 box of cereal. The U.S. net retail profit is about 5 cents.[3]

Manufacturer

A maker of products. Manufacturers assemble, refine, or otherwise transform materials into a developed product.

$1.40 USD The amount added to the U.S. economy for every $1.00 spent in manufacturing – the highest multiplier effect of any economic sector. The manufacturing industry is a critical part of a national economy.[4]

Visibility

Knowing where products are located, the ability to monitor order progress, and the ability to anticipate unplanned events in the supply chain.[7]

96% Percentage of electronics manufacturers who said that lack of visibility increases risks in the supply chain – like long lead times, extra shipping time, and difficulty managing their capacity.[8]

Microsoft

Sources. 1: Paul Myerson: Introduction to Supply Chain and Logistics Management Made Easy, April 2015 2: Supply Management: The top five supply chain disruptions of 2014, 2015 3: Project44: Global Supply Chain Statistics, 2015 4: National Association of Manufacturers: Top 20 Facts About Manufacturing, 2015 5: Statista: Global digital music industry revenue 2015-2020, 2016 6: GS1 US: RFID is Gaining Traction, 2015 7: Red Prairie: The Struggle for Visibility in Global Supply Chains, 2011 8: Jabil: 2015 Supply Chain Trends [Infographic]

Operations Management of Logistics and Supply Chain

- Organizations adopt numerous business improvement methodologies to improve business performance.

- Logistics and supply chain management are regarded to be the crucial factor for the companies to obtain competitive edge.

Source: Operations Management of Logistics and Supply Chain, 2014

Logistics as process

- Logistics is the **process** of planning, implementing, and controlling the efficient, effective **flow and storage of goods**, **services**, and related **information** from point of origin to point of consumption for the purpose of conforming to customer requirements

Source: Council of Supply Chain Management Professionals

Logistics management

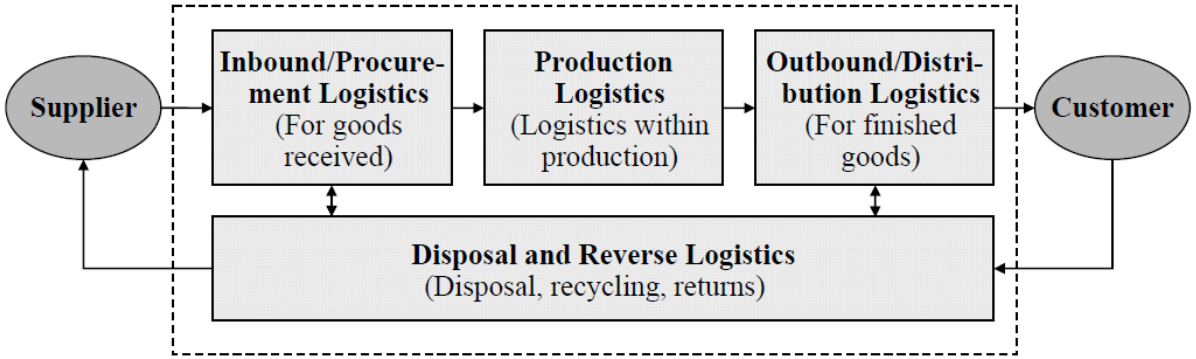
- Logistics is the management of **the flow of goods** between the point of origin and the point of consumption in order to meet some requirements, for example, of customers or corporations.
- The resources managed in logistics can include **physical items, such as food, materials, animals, equipment, and liquids, as well as abstract items, such as time, information, particles, and energy**.
- The logistics of physical items usually involves the integration of information flow, material handling, production, packaging, inventory, transportation, warehousing, and often security.

Source: Operations Management of Logistics and Supply Chain, 2014

Logistics

Logistics can be differentiated into :

1. Inbound logistics for purchased goods
2. Production logistics in production
3. Distribution logistics for finished goods
4. Disposal and reverse logistics for recycled, returned or disposed goods



Source: Corsten & Gössinger 2001

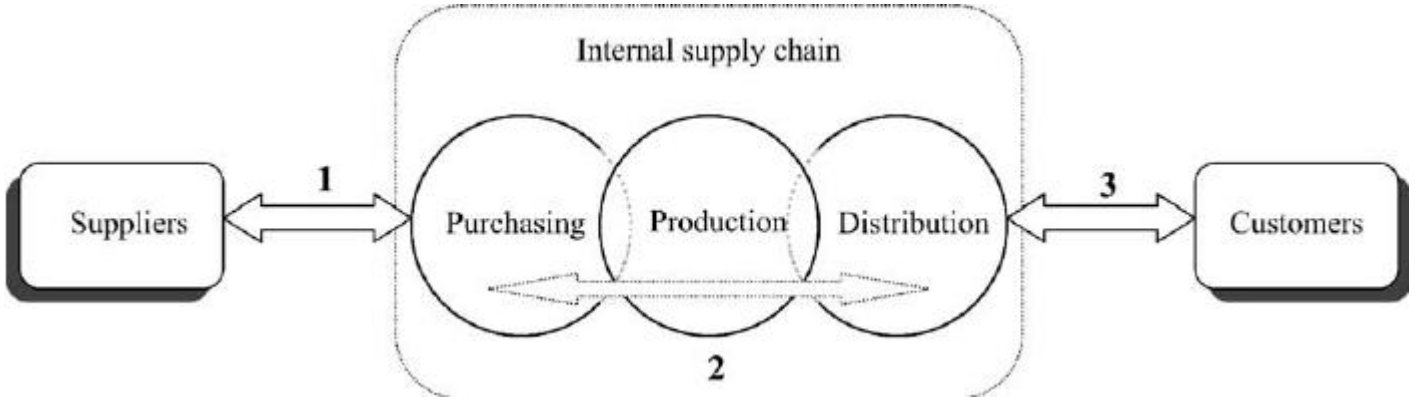
Supply chain

- Both supply chain and logistics are relevant to the **product circulation** during its whole life cycle, and both have been regarded as the central unit for competitive analysis.

- Supply chain can be seen as a broader concept with a wider range, as it can involve **network sourcing, supply pipeline management**, **value chain management and value stream management**.

Source: Operations Management of Logistics and Supply Chain, 2014

Supply chain - Internal



Understanding the supply chain is essential, so mapping out any uncertainties greatly helps in the management.

Source: Chen & Paulray (2004)

Uncertainty defined in scientific literature

Uncertainty in the supply chain can come from:

1. Supplier uncertainty, arising from on-time performance, average lateness and degree of inconsistency

2. Manufacturing uncertainty, arising from e.g. process performance, machine breakdown, supply chain performance.

3. Customer or demand uncertainty, arising from e.g. forecasting errors, irregular orders.

Environmental uncertainty

1. Supply uncertainty includes indicators that represent quality, timeliness and the inspection requirements of the suppliers.
2. Demand uncertainty is measured in terms of fluctuations and variations in demand.
3. Technology uncertainty measures the extent of technological changes evident within the industry.

Source: Chen & Paulray (2004)

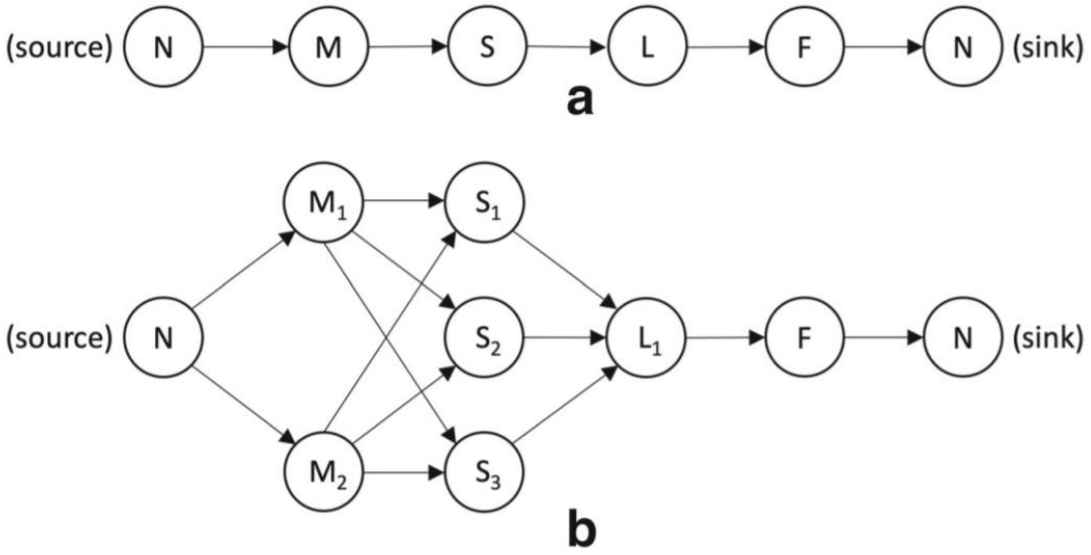
Need-driven supply chain

Customer focus

- Level of importance given to customers in the execution of strategic planning, quality initiatives, product customization and responsiveness.
- In general, the more attention a company pays to researching its customer base in order to identify customer needs, the more rewarding the exchange transaction in the supply chain will be for that company.
- Despite the use of the latest process improvement techniques and capable management, a firm's neglect of its customers may lead to disaster. A need-driven approach to the supply-chain is therefore very suitable.

Source: Chen & Paulray (2004), (Carson et al., 1998); (Kordupleski et al., 1993)

Need-driven approach



Need analysis and filtering as a network. (**a**) The vertex *N* contains a set of needs that flow through stages of market analyses *M*, stakeholder analyses *S*, and landscape analyses *L* to reach a filtered state *F* that yields a set of final needs. (**b**) The vertex for market analyses can be further seperated, with M_1 taking a top-down approach and M_2 a bottom-up. Stakeholder analyses can be split into in-depth interviews or re-immersions S_1, shorter interviews or phone calls S_2, and online research S_3. L_1 represents a single approach to landscape analyses to be conducted, but others could be added

Source: Soliman et al (2020)

Top management support

- Research has shown that top management must be aware of the competitive benefits that can be derived from the impact of **strategic purchasing and information technology** on effective supply relationships.

- Top management support can be characterized in terms of **time and resources contributed by the top management to strategic purchasing, supplier relationship development and adoption of advanced information technology**.

Source: Hahn et al. (1990), Monczka et al. (1993), Krause and Ellram (1997)

Competitive priorities

- Competitive priorities are used to describe manufacturers' choice of manufacturing tasks or key competitive capabilities, which are broadly expressed in terms of low cost, flexibility, quality, and delivery.

- This provides the following dimensions for competitive priorities:

- Quality
- Lead-time
- Cost
- Flexibility

Source: Skinner (1969), Hayes and Wheelwright (1984)

Competitive priorities

Dimensions of quality:

- Performance - the primary operating characteristics.
- Features - optional extras (the "bells" and "whistles").
- Reliability - likelihood of breakdown.
- Conformance - conformance to specification.
- Technical durability - length of time before the product becomes obsolete.
- Serviceability - ease of service
- Aesthetics - look, smell, feel, taste.
- Perceived quality - reputation.
- Value for money.

Competitive priorities

Dimensions of time:

- Manufacturing lead time.
- Due date performance.
- Rate of product introduction.
- Delivery lead time.
- Frequency of delivery.

Competitive priorities

Dimensions of price and cost:

- Manufacturing cost.
- Value added.
- Selling price.
- Running cost - cost of keeping the product running.
- Service cost - cost of servicing the product.
- Profit.

Competitive priorities

Dimensions of flexibility

- Material quality - ability to cope with incoming materials of varying quality.
- Output quality - ability to satisfy demand for products of varying quality.
- New product - ability to cope with the introduction of new products.
- Modification - ability to modify existing products.
- Deliverability - ability to change delivery schedules.
- Volume - ability to accept varying demand volumes.
- Product mix - ability to cope with changes in the product mix.
- Resource mix - ability to cope with changes in the resource mix.

Information technology to improve competitive priorities

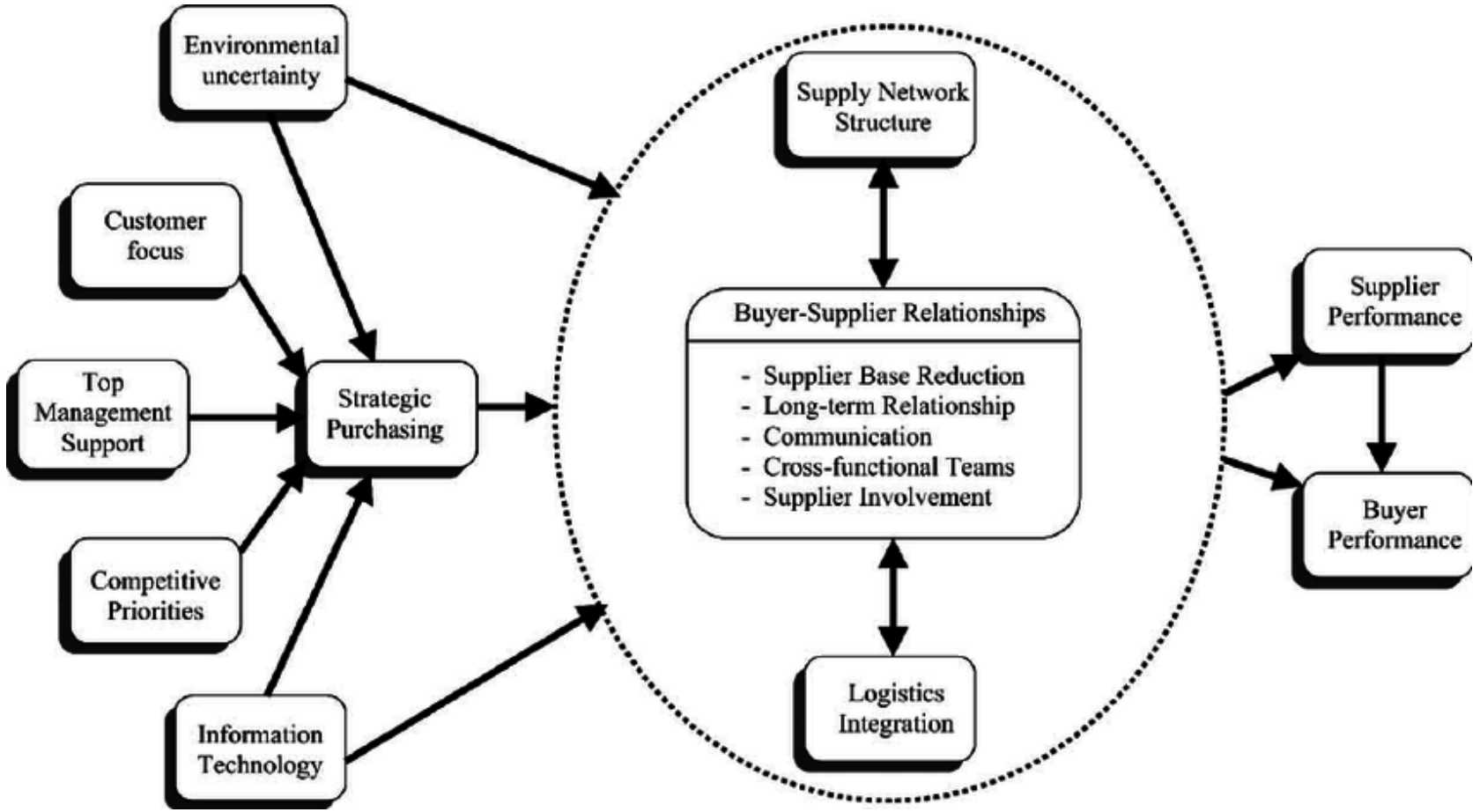
- The term “information technology” includes computers, ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance), peripheral equipment designed to be controlled by the central processing unit of a computer, software, firmware and similar procedures, services (including support services), and related resources.

- It is captured as the presence of electronic transactions and communication in various forms between the supply chain partners

- It requires the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged (**interoperability**).

Source: Greis and Kasarda (1997), Carr and Pearson (1999), HIMSS 2010, Federal Register

Supply chain – Theory based on literature



Source: Chen & Paulray (2004)

Supply chain management (SCM)

The term SCM has been used to explain the **planning and control** of materials and information flows as well as the logistics activities not only internally within a company but also externally between companies.

The concept of Supply Chain Management (SCM) is based on two key ideas:

- The first is that practically every product that reaches an end user represents the **cumulative effort** of multiple organizations. These organizations are referred to collectively as the supply chain.
- The second idea is that while supply chains have existed for a long time, most organizations have only paid attention to what was happening within their own company. The **entire chain of activities** that ultimately delivered products to the final customer was often not well understood let alone managed. The result was disjointed and often ineffective supply chains.

Source: NC State University; (Cooper et al., 1997b; Fisher, 1997)

Supply chain management (SCM)

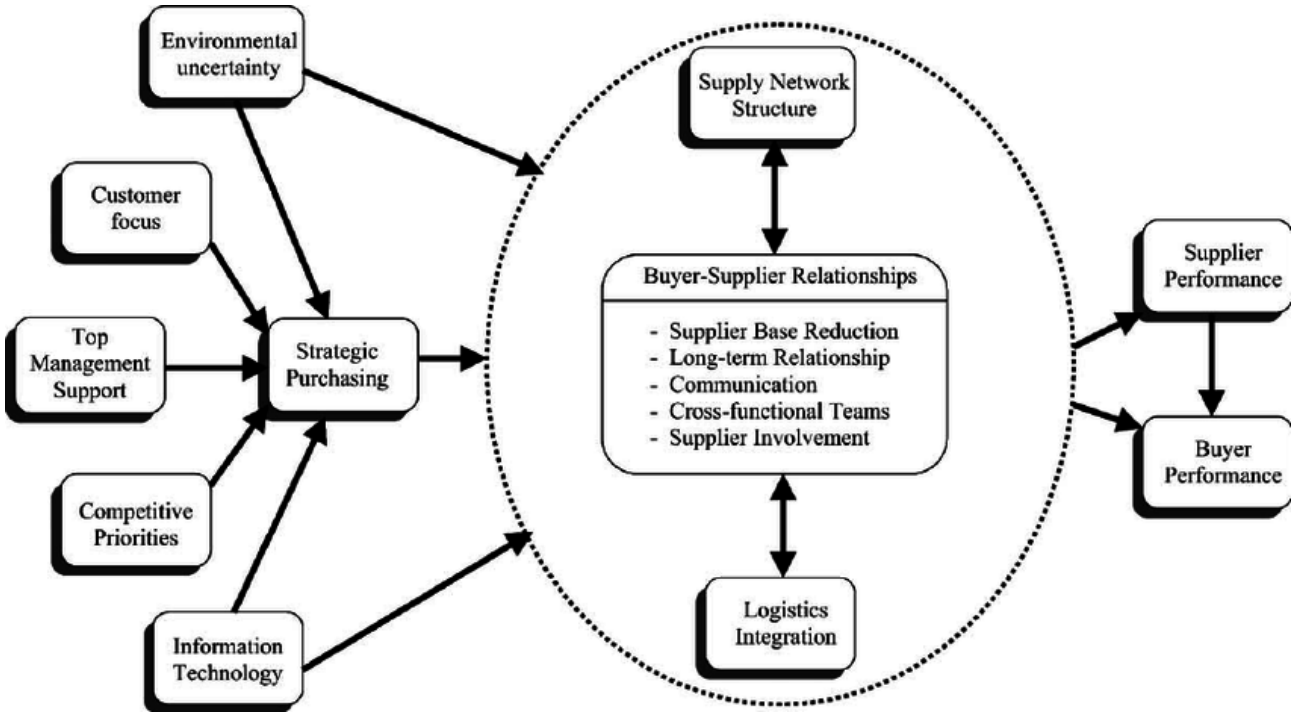
- The organizations that make up the supply chain are “linked” together through physical flows and information flows.
- **Physical flows** involve the transformation, movement, and storage of goods and materials. They are the most visible piece of the supply chain.
- **Information flows** allow the various supply chain partners to coordinate their long-term plans, and to control the day-to-day flow of goods and materials up and down the supply chain.

Source: NC State University

Supply chain

- Think about the supply chain factors.

- What do you “purchase”?
- What do you “produce”?
- What do you “distribute”?



An important practical factor is queuing

- Both logistics and supply chains are affected by queuing.
- Queuing is the amount of time a person, signal, or item spends before being attended to, or before value adding work is performed to or on it.
- It has been suggested that in many factories queue time makes up the majority of the total lead time.

Source: businessdictionary, 2017

Queuing

- A queuing system consists of discrete objects we call **items** that "arrive" at some rate into the system. Within the system the items may form one or multiple queues and eventually receive “service” and exit.
- Items in the system might be in queue, service or both.

- We don’t assume FIFO (first-in and first-out), so we consider the whole system as a queue plus service.

Source: doi: 10.1007/978-0-387-73699-0

Queuing

Little's Law (essentially a mathematical Theorem) asserts that the time average number of items in a queueing system (L) is equal to the product of the average rate at which items arrive per unit time and enter the system (λ) AND the average waiting time of a item (W).

$$L = \lambda W$$

Source: doi: 10.1007/978-0-387-73699-0

Queuing

Little's Law asserts that the time-average number of items in a queueing system (L) is equal to the product of the average rate at which items arrive per unit time and enter the system (λ), as well as the average waiting time of a item (W).

$$L = \lambda W$$

This requires a stationarity assumptions of the underlying stochastic processes.

Source: doi: 10.1007/978-0-387-73699-0

Example

- The number of items in the queuing system over time *n(t), which is known*
- Time period (*T*) starts at 3 and ends at 20 days
- *N(T)* is number of cumulative **arrivals**
- Arrival rate during *T*

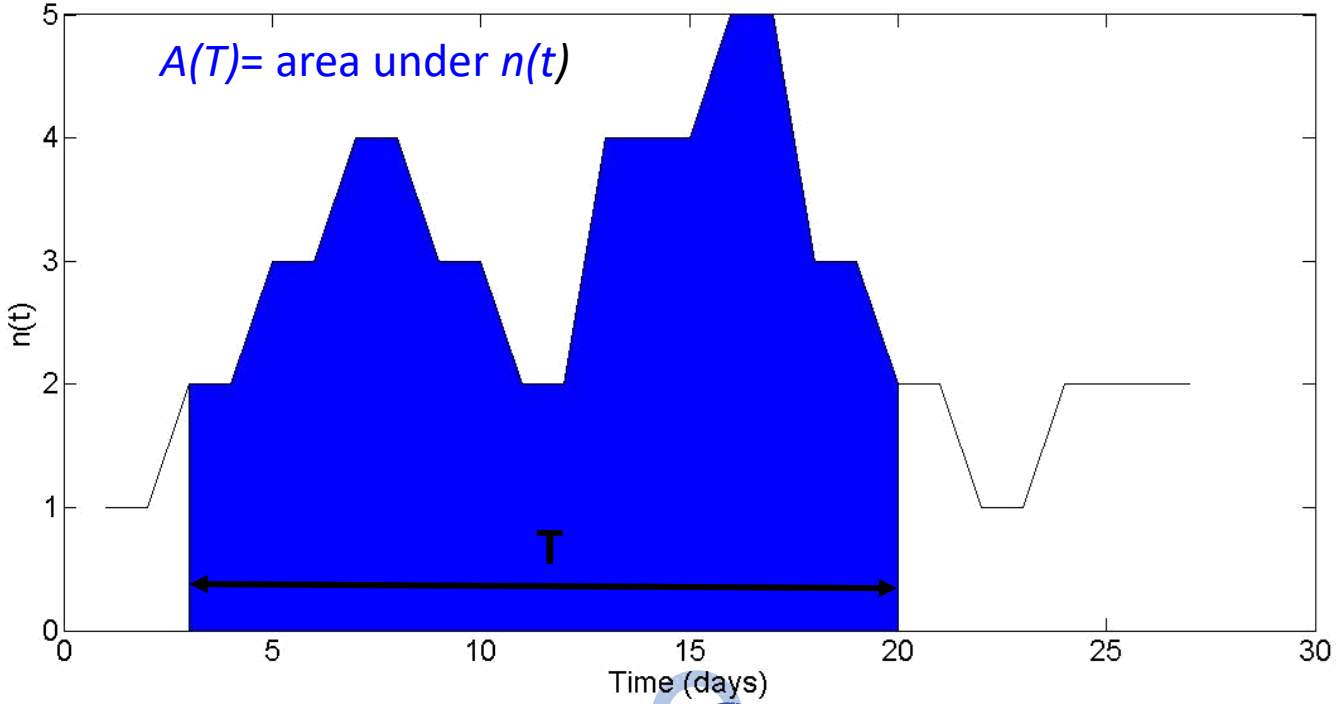
$\lambda(T)=N(T)/T \approx 0.3$

- Average queue length during T

$L(T)=A(T)/T \approx 3.3$

- Average waiting time during T

$W(T)=A(T)/N(T) \approx 11.2$



Example

- The number of items in the queuing system over time *n(t), which is known*

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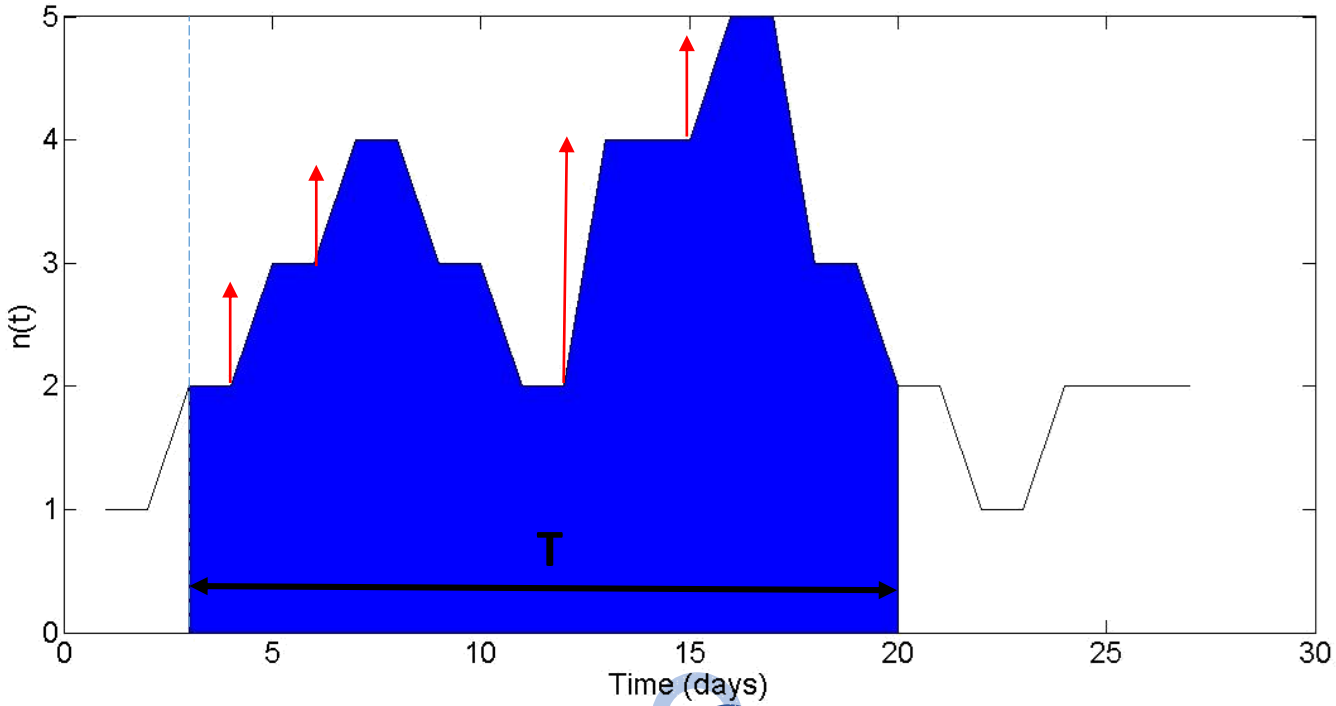


Example 2

- The number of items in the queuing system over time *n(t)*
- Time period (*T*) starts at 3 and ends at 20 days – **Unknown priors and *L(t)* is unknown**
- *N(T)* is number of cumulative **arrivals**
- **Arrival** rate during *T*

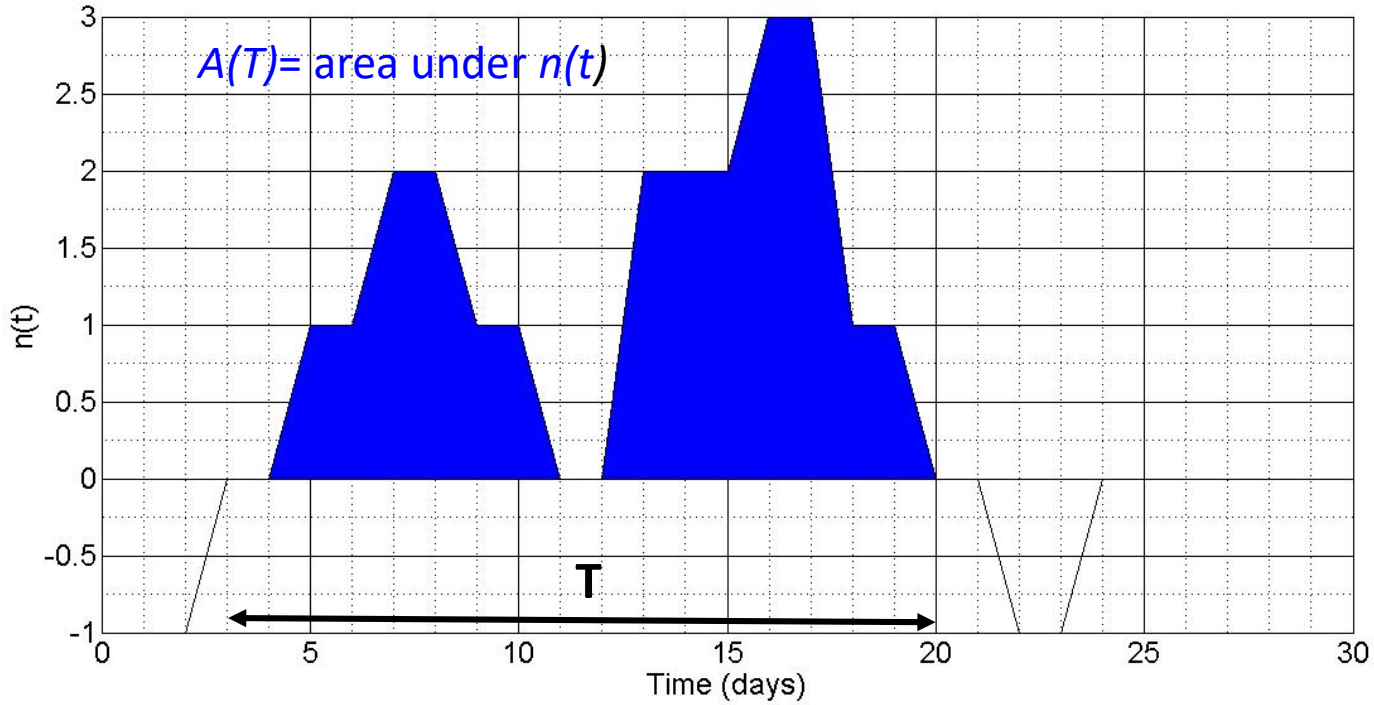
$\lambda(T)=N(T)/T \approx 0.3$

- Average queue length during T

$L(T)=A(T)/T \approx 1.3$

- Average waiting time during T

$W(T)=A(T)/N(T) \approx 4.4$



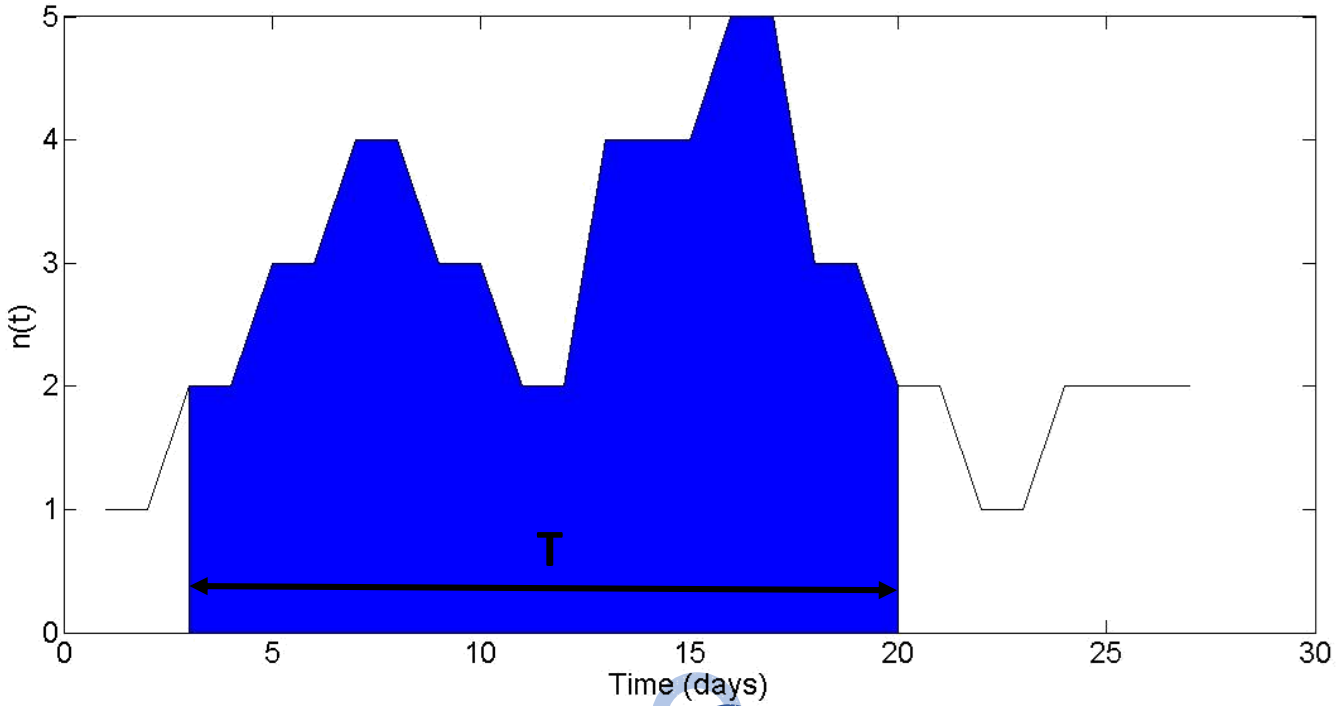
Queuing

- Keep in mind the stochastic nature (*{X(t)}* - random probability distribution)
- Keep in mind end effects (inclusion of waiting of items before *T* and exclusion of items arrived during *T* but not yet left)

$$\lim_{T\to\infty} L(T) = L$$

$$\lim_{T\to\infty} \lambda(T) = \lambda$$

$$\lim_{T\to\infty} W(T) = W$$

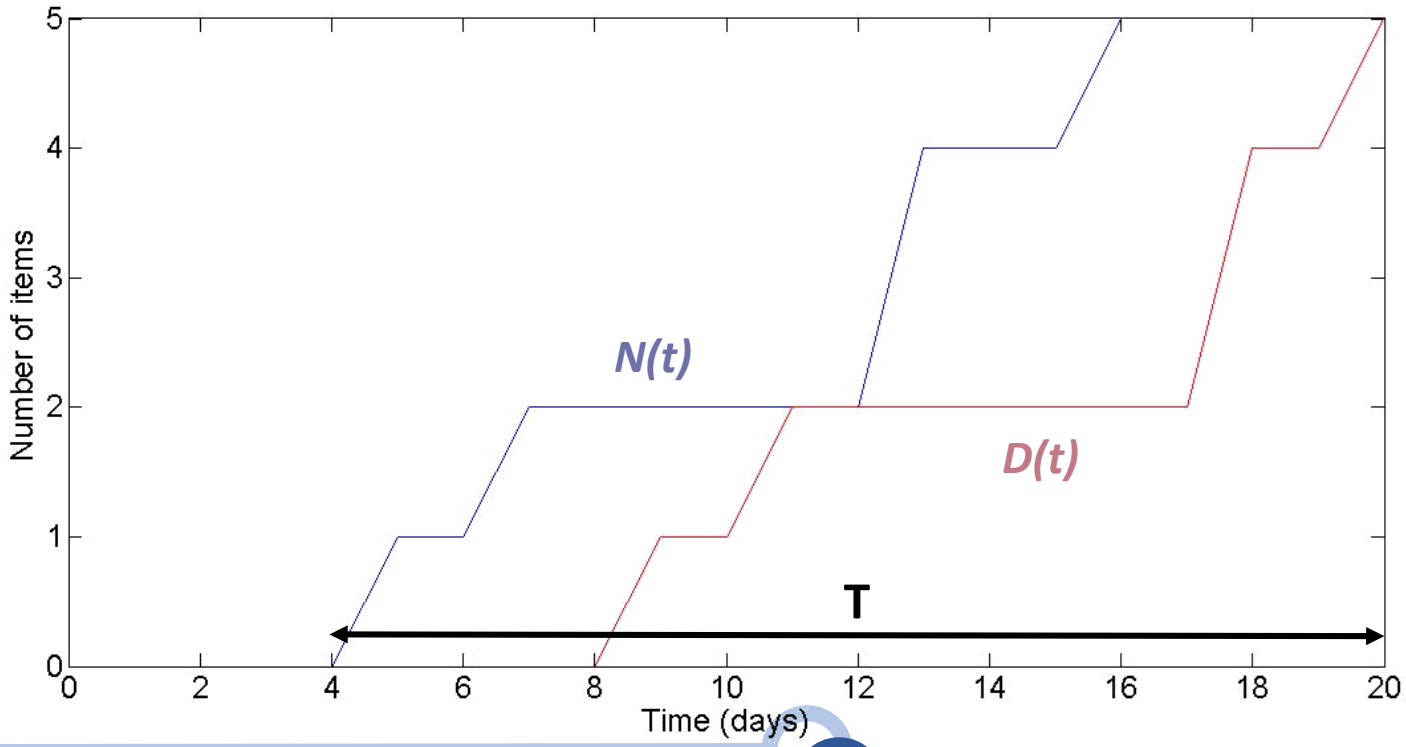


Queuing – average queue length

- *N(t)* is number of cumulative arrivals
- *D(t)* is number of cumulative departures

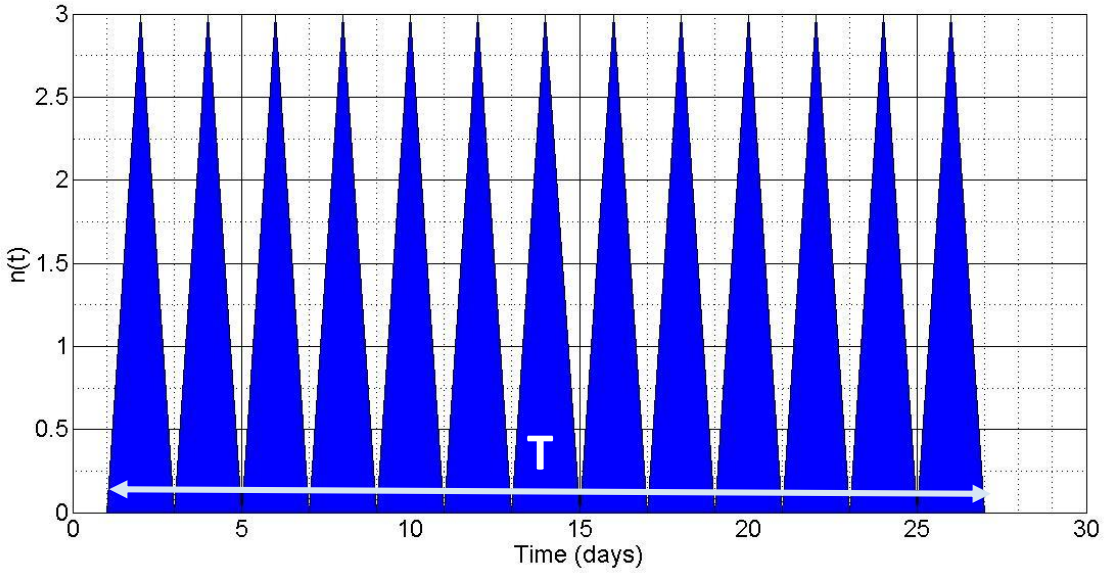
Based on N(t) and D(t), not on what is in the system

$$L = T^{-1} \int_{t_n=0}^{t_n=T} \big(N(t_n) - D(t_n)\big) dt_n$$



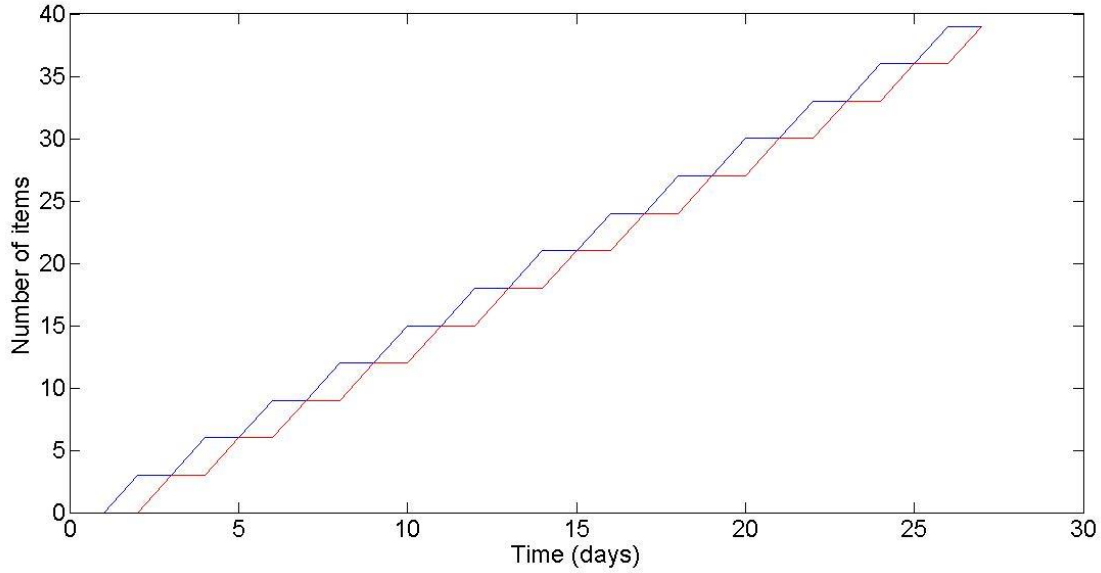
Source: doi: 10.1007/978-0-387-73699-0

Queuing – average waiting time



Average waiting time during *T*

$$W(T) = N(T)^{-1}A(T) = 1$$
$$\lambda(T) = 1.5$$



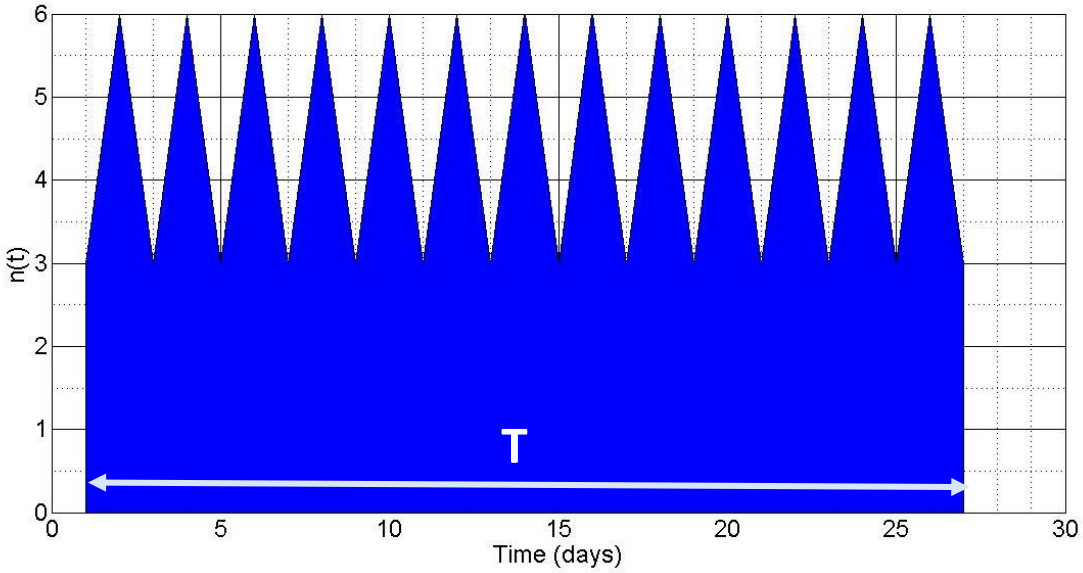
Average waiting time during *T*

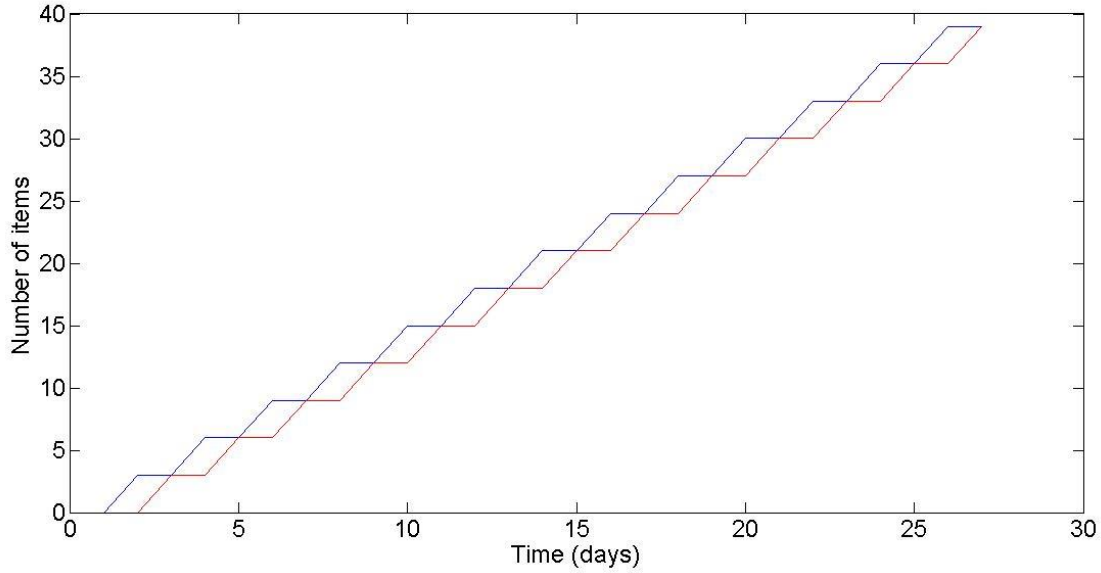
$$W(T) = N(T)^{-1}\int_{t_n=0}^{t_n=T}\big(N(t_n) - D(t_n)\big)dt_n = 1$$
$$\lambda(T) = 1.5$$

Queuing – average waiting time

Effect of offset

A queue may never go to zero in *[0 T]* and *n(0)>0* as well as *n(T)>0*





Average waiting time during *T*

$$W(T) = N(T)^{-1}A(T) = 3$$
$$\lambda(T) = 1.5$$

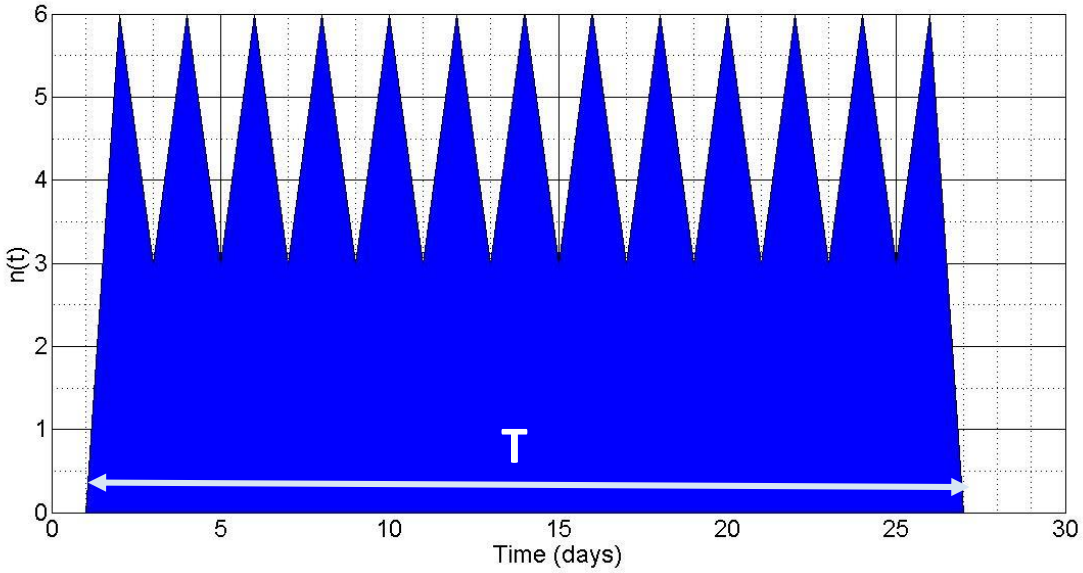
Average waiting time during *T*

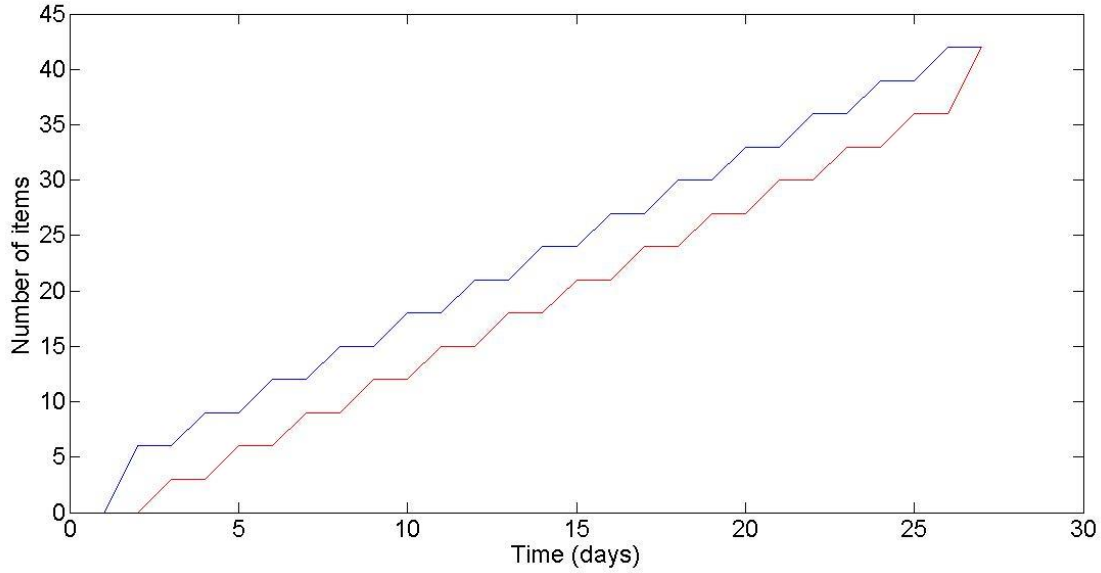
$$W(T) = N(T)^{-1}\int_{t_n=0}^{t_n=T}\big(N(t_n) - D(t_n)\big)dt_n = 1$$
$$\lambda(T) = 1.5$$

Queuing – average waiting time

Effect of offset

A queue may never go to zero in *[0 T]* and *n(0)>0* as well as *n(T)>0*





Average waiting time during *T*

$$W(T) = N(T)^{-1}A(T) = 2.7143$$
$$\lambda(T) = 1.6154$$

Average waiting time during *T*

$$W(T) = N(T)^{-1}\int_{t_n=0}^{t_n=T}\big(N(t_n) - D(t_n)\big)dt_n = 2.7143$$
$$\lambda(T) = 1.6154$$

Queuing in Operations Management

- *TH* =Throughput, the average output of a production process (machine, workstation, line, plant) per unit time
- *WIP* = Work In Process, the inventory between the start and end points of a product routing
- CT = Cycle Time (or flow time), the average time from release of a job at the beginning of the routing until it reaches an inventory point at the end of the routing (that is, the time the part spends as *WIP).*

$$\overset{\lambda}{TH} = \frac{\overset{L}{WIP}}{\overset{W}{CT}}$$

Source: doi: 10.1007/978-0-387-73699-0

Queuing in supply

- If we take inventory (*I*) and keep throughput (*TH*) and cycle time (*CT*) we obtain

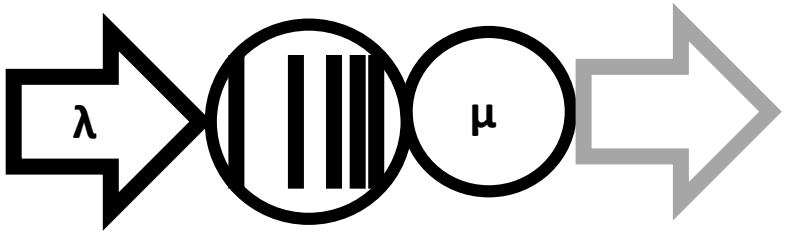
$$TH = \frac{I}{CT}$$

- Throughput is the rate at which an item is received and is sold out of stock

Kendall's notation for queues

Arrival distr.
Poisson – Markovian (M)
Service time distr.
Poisson – Markovian (M)
Server number
Number of servers (1)

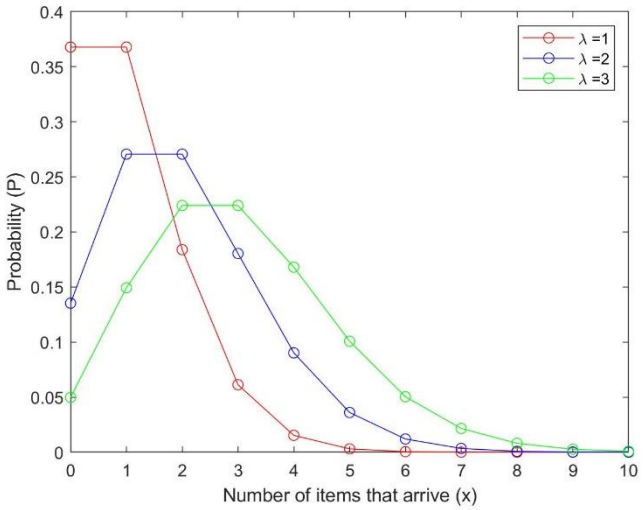
M/M/1 queue



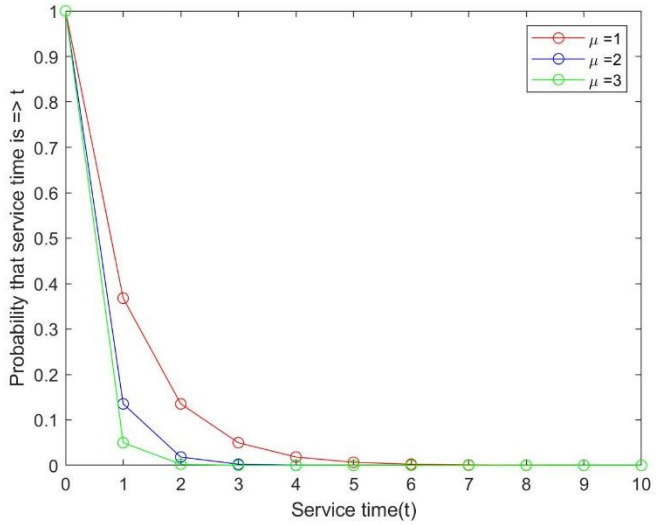
Waiting node Service node

Single waiting area, where arriving follows a Poisson point process and a simple service distribution that follows the exponential distribution.

$$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!}$$



Discrete contribution



$$P(t) = e^{-\mu t}$$

M/M/1 queue

A *M/M/1* queue is one in which there is one ”machine” and both the inter-arrival time and service time are exponentially distributed.

The average utilization of the system (ρ) is given by:

$$\rho = \frac{\lambda}{\mu}$$

with μ being the mean service rate ($\frac{1}{T_{service}}$)and λ is mean arrival rate, ρ is also known as traffic intensity.

The mean number of items in the **queue** (L_q) is given by

$$L_q = \frac{\rho^2}{1-\rho} = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

Thus, the wait in the **queue** (W_q) is

$$W_q = \frac{L_q}{\lambda} = W - \frac{1}{\mu} = \frac{\lambda}{\mu(\mu-\lambda)}$$

Recap: An exponential distribution with a mean of $\frac{1}{\lambda}$ has a variance of $\frac{1}{\lambda^2}$

The mean number of items in the **system** is given by

$$L = L_q + \frac{\lambda}{\mu}$$

The mean time an item spends in the **system** is

$$W = W_q + \frac{1}{\mu}$$

Queuing theory

- Queuing theory is mathematical method of analysing the congestions and delays of waiting

- Define a waiting/queuing problem when a team of max 4 technicians have to attend to 30 users.

- For example think about managing the evaluation of information “sets” handed out (arrival / departure)

Questions?

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Management Practice

4. Financial

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to read financial statements
- Able to check if financial statements are correct
- Understand cost for R&D
- Able to explain life cost against time

Literature for this session:

Gombola, Michael J., and J. Edward Ketz. "A note on cash flow and classification patterns of financial ratios." Accounting Review (1983): 105-114.

Importance of finance

Some quotes:

“You have to understand accounting and you have to understand the nuances of accounting. It’s the language of business “

Warren Buffet, investor, industrialist and philanthropist

“The importance of money flows from it being a link between the present and the future.”

John Maynard Keynes, one of the most famous 20th-century economist

Lets start with the basics

Image source: Chriahcorp

Financial statements

- The financial statements often also provides additional background information, such as how the value of an asset has been determined.
- The statement is only as good as the data that is entered
- Robust predictions require complex comparative analysis to determine trends.

Key components of financial statement

- **Profit and loss account** (P&L) or income statement outlines how much have been earned during the year and what is available to invest or give back to shareholders.
- **Balance sheet** provides a snapshot of what the business owns, less any amounts payable to other parties on a particular day (usually end of financial year).
- **Cash flow statement** shows were cash is coming into and being used in running the business. It helps to determine its ability to meet its short-term liabilities, such as paying bills or repayment on loans.

Source: You do the math, Claire Warren

Interaction between components

- The components interact with one another.

- For example: Equipment bought on Loan

P&L (12 months)	Balance Sheet (End of period)	Cash Flow (Continuously)
Depreciation of equipment (no cash)	**Asset: Equipment** (– Depreciation)	**Cash paid for equipment** (+VAT)
	Asset: VAT back as receivable (once)	**Loan**
Interest on loan	**Liability: Loan**	**Loan interest**

Profit and loss account

- It shows how the money received from sale of products and services is transformed into income.

- Very simply said it shows if the company makes a profit or a loss.

Profit and loss account	2016	2017	% change
Revenue	173 843	209 891	21
Cost of sales	94 742	115 433	
Gross profit	79 101	94 458	19
Gross margin	46%	45%	
Administration and distribution expenses	55 790	67 405	
Operating profit	**23 311**	**27 053**	16
Operating margin	13%	13%	
Finance cost	1 404	1 049	
Finance income	1	1	
Profit before Tax	**21 908**	**26 005**	19
Income tax expense	6 333	7 521	
Profit for the year	**15 575**	**18 484**	19
After-tax profit percentage	9%	9%	

Accountant will normally have the latest year at the front

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After-tax profit percentage	9%	9%	

Revenue (or turnover) is the amount that is made through the sale of products and services.

Profit and loss account	2016	2017	% change
Revenue	173 843	209 891	21
Cost of sales	94 742	115 433	
Gross profit			
Gross margin			
Administration and distribution expenses			
Operating profit			
Operating margin	13%	13%	
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Cost of sales are the cost directly attributed to the production or purchase of whatever the company sells or delivers and includes salary cost for employees directly involved in the production or delivery of process.

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Revenue	173 843	209 891	21
Cost of sales	94 742	115 433	
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Gross margin			
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Operating profit			
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After-tax profit percentage	9%	9%	

Gross profit is the difference between revenue and costs of sales (e.g. 209891-115433=94458). It is the direct margin of what the company makes. A healthy business will aim to increase profit year on year.

Profit and loss account	2016	2017	% change
Revenue	173 843	209 891	21
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Gross margin	46%	45%	
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Operating profit	**23 311**	**27 053**	16
Operating margin			
Finance cost			
Finance income			
Profit before Tax			
Income tax expense	6 333	7 521	
Profit for the year	**15 575**	**18 484**	19
After-tax profit percentage	9%	9%	

Operating profit is the profit or net income generated through business operations. It is after deduction of direct costs of sales and indirect expenses (e.g. administration & pension costs)

Profit and loss account	2016	2017	% change
Revenue	173 843	209 891	21
Cost of sales	94 742	115 433	
Gross profit	79 101	94 458	19
Gross margin	46%	45%	
Administration and distribution expenses	55 790	67 405	
Operating profit	**23 311**	**27 053**	16
Operating margin			
Finance cost			
Finance income			
Profit before Tax			
Income tax expense			
Profit for the year	**15 575**	**18 484**	19
After-tax profit percentage	9%	9%	

Profit of the year takes into account any income or expenses relating to how the company is financed, as well as income tax. It shows the profit that can be paid out to shareholders in the form of dividends or retained within the business.

Balance sheet

- It shows the financial position of the company on a particular day and shows the total value of the net assets (assets minus liabilities) and working capital (Working Capital = Current Assets - Current Liabilities).

- In other words the sheet shows what the business owns (assets) and owes (liabilities).

- A balance sheet should be in balance!!

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
Property, plant and equipment	57 947	62 216
Total non-current assets	**60 756**	**69 015**
Current assets		
Inventory	21 560	23 304
Trade and other receivables	22 812	26 466
Cash and cash equivalents	20	1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
Issued capital and capital reserves	5 500	5 500
Retained earnings	29 306	42 176
Total equity	**34 806**	**47 676**
Non-current liabilities		
Deferred tax	17 384	17 457
Provisions	14 882	18 537
Interest bearing loans and borrowings	12 110	15 711
Current liabilities		
Trade and other payables	9 650	11 528
Income tax	1 917	1 789
Interest-bearing loans and borrowings	10 527	4 582
Provisions	3 872	4 025
Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

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Total assets	**105 148**	**120 305**

Assets are anything (in)tangible that can be owned or controlled to produce a positive economic value.

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
Issued capital and capital reserves	5 500	5 500
Retained earnings	29 306	42 176
Tota		**47 676**
Non		
Deferred tax	17 384	17 457
Provisions	14 882	18 537
Interest bearing loans and borrowings	12 110	15 711
Current liabilities		
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Provisions	3 872	4 025
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Total equity and liabilities	**105 148**	**120 305**

Non-current assets are assets that would not be turned into cash within a year.

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
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Non[illegible]		
Def[illegible]	[illegible]	17 457
Prov[illegible]	[illegible]	18 537
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Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Intangible assets do not have a physical nature and include patents, brands and customers lists. They are usually spread over the period that they are perceived to have value (*amortisation*).

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Assets		
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Non-current liabilities		
Deferre		7 457
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Property, plant and equipment (*PP&E*) are physical assets that are used in day-to-day activities and include buildings and machinery. These are used over time and a charge is made to the P&L over the lifetime of the assets.

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
Property, plant and equipment	57 947	62 216
Total non-current assets	**60 756**	**69 015**
Current assets		
Inventory	21 560	23 304
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Current liabilities		
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Interest-bearing loans and borrowings	10 527	4 582
Provisions	3 872	4 025
Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Current assets are assets that can be turned into cash within a year.

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
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Current assets		
Inventory	21 568	23 304
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Provisions	3 872	4 025
Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Inventory is stock held by the business that will either be sold or used in manufacturing or development. It is current as it normally held for less then a year.

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
Property, plant and equipment	57 947	62 216
Total non-current assets	**60 756**	**69 015**
Current assets		
Inventory	21 560	23 304
Trade and other receivables	[illegible]	[illegible]
Cash and cash equivalents	20	1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

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Equity attributable to equity holders of the parent		
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Current liabilities		
Trade and ot		8
Income tax		
Interest-bear		
Provisions	3 872	4 025
Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Trade and other receivables is also known as **debtors** and it is the amount owed to the company by third parties. This also includes VAT.

Balance Sheet - Assets	2016	2017
Assets		
Non-current assets		
Intangible assets	2 809	6 799
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Income tax		9
Interest-bea		2
Provisions		5
Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Cash and cash equivalents are considered to be the most liquid assets. Cash equivalents may be converted into cash within three months and include short-term government bonds and treasury bills. Movements in the cash balances are shown in the cash flow statement.

Balance Sheet - Assets	2016	2017
Assets		
	9	6 799
	47	62 216
	56	**69 015**
Current assets		
Inventory	21 560	23 304
Trade and other receivables	22 812	26 466
Cash and cash equivalents	20	1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

Total equity is the value of assets that is left after all liabilities have been paid. It is the amount that shareholders can make a claim on. It contains the initial value of the shares plus the earnings that have been retained within the company (e.g. not been paid out as dividends to shareholders).

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
Issued capital and capital reserves	5 500	5 500
Retained earnings	29 306	42 176
Total equity	**34 806**	**47 676**
Non-current liabilities		
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Cash and cash equivalents	20	1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

Non-current liabilities are obligations that a company does not have to settle normally within an (accounting) year.

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
Issued capital and capital reserves	5 500	5 500
Retained earnings	29 306	42 176
Total equity	**34 806**	**47 676**
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Total assets	**105 148**	**120 305**

Deferred Tax is an accounting term that is normally used to describe the tax payments that need to be paid in the future due to current activities.

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
Issued capital and capital reserves	5 500	5 500
Retained earnings	29 306	42 176
Total equity	**34 806**	**47 676**
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Cash and cash equivalents	20	1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

Provisions are liabilities for which the timing or amount of payment is uncertain, such as litigation cost or rising pension scheme deficits.

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Equity attributable to equity holders of the parent		
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		26 466
		1 520
Total current assets	**44 392**	**51 290**
Total assets	**105 148**	**120 305**

Trade and other payables, also known as **creditors**, represents amounts payable for goods and services provided by a third party.

Balance Sheet – Equity and liabilities	2016	2017
Equity attributable to equity holders of the parent		
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Retained earnings	29 306	42 176
Total equity	**34 806**	**47 676**
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	92	**51 290**
Total assets	**105 148**	**120 305**

Income tax. At the end of the year the company calculates its net profit and estimates its tax liability.

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Total liabilities	**70 342**	**72 629**
Total equity and liabilities	**105 148**	**120 305**

Cash Flow Statement

- Cash is the lifeblood of the company. A profitable business can still go into administration if it can’t pay their immediate bills.

- A healthy and growing company would normally spend and invest most of their cash to ensure income in the future.

Cash Flow Statement

- The cash flow statement illustrates the movement of cash into and out of the company over a financial period (normally a year).
- **Net cash flow** is the term used to describe all cash received by the company over that period, minus the cash paid out. This is not the same as profit in the P&L, which consists of the income recorded when its earned and the liabilities when they arise, independent if whether cash has been received or paid.
- Depreciation of equipment does not come back in the cash flow statement. This is set as a given part of the total investment, which defined by the government (e.g. how much can you depreciate it per year).
- Paid investments and VAT (e.g. buying new equipment) will show up in cash flow, but not in profit and loss.

Cash flow statement	2016	2017
Cash flows from operating activities		
Profit before tax and finance cost	23 311	27 053
Depreciation and amortisation	5 489	6 088
Loss on disposal of plant	180	250
Operating cash flows before changes in working capital and provisions	28 980	33 391
(Increase) in net current assets	840	1 661
Additional cash contribution to reduce deficits (e.g. pension deficit)	1 400	1 600
Increase/(decrease) provision	648	634
Cash generated from operations	**27 388**	**29 496**
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Cash flow statement	2016	2017
Net cash flows from operating activities	**19 972**	**21 049**
Cash flows from investing activities		
Proceeds from disposal of plant	98	135
Purchase of property, plant and equipment	5 742	6 539
Acquisition of subsidiaries	916	4 000
Net cash flows from investing activities	**6 560**	**10 404**
Cash flows from financing activities		
Dividends paid	3 960	5 200
Receipts of new bank loans	4 527	2 000
Repayment of bank loans	13 000	6 000
Net cash flows from financing activities	**12 433**	**9 200**
Net Increase in cash/cash equivalents	979	1 445
Cash/cash equivalents at 1st January	959	20
Cash/cash equivalents at 31st December	**20**	**1 465**

Cash flow statement	2016	2017
Cash flows from operating activities		
Profit before tax and finance cost	23 311	27 033
Depreciation and amortisation	5 489	6 088
Loss on disposal of plant	180	250
Operating cash flows before changes in working capital and provisions	28 980	33 391
(Increase) in net current assets	840	1 661
Additional cash contribution to reduce deficits (e.g. pension deficit)	1 400	1 600
Increase/(decrease) provision	648	634
Cash generated from operations	**27 388**	**29 496**
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Cash flow statement	2016	2017
		1 049
		135
		6 539
		4 000
		0 404
		5 200
		2 000
		6 000
Net cash flows from financing activities	**12 433**	**9 200**
Net Increase in cash/cash equivalents	979	1 445
Cash/cash equivalents at 1st January	959	20
Cash/cash equivalents at 31st December	**20**	**1 465**

Cash flows from operating activities arise from the revenue producing activities of the business, including day-to-day trading. The best way is to start with the profit before tax and finance cost (see P&L).
This is then adjusted for accounting entries that do not relate to the exchange of cash, such as depreciation and amortisation, any losses made on the sale of assets (value of asset was greater then the cash received upon sale) and changes in provisions for future liabilities.

It is also important to make changes in net current assets (working capital). If the stock of a company rises from £10 000 to £15 000 then an additional £5 000 will be tied up in stock (cash outflow increase).

Cash flow statement	2016	2017
		27 053
		6 088
Loss on disposal of plant	180	250
Operating cash flows before changes in working capital and provisions	28 980	33 391
(Increase) in net current assets	840	1 661
Additional cash contribution to reduce deficits (e.g. pension deficit)	1 400	1 600
Increase/(decrease) provision	648	634
Cash generated from operations	**27 388**	**29 496**
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Net cash flows from operating activities consists of combining the cash generated from operations with the cash flow on interest paid, interest received and income tax paid.

Cash flow statement	2016	2017
Net cash flows from operating activities	**19 972**	**21 049**
Cash flows from investing activities		
Proceeds from disposal of plant	98	135
Purchase of property, plant and equipment	5 742	6 539
Acquisition of subsidiaries	916	4 000
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Net Increase in cash/cash equivalents	979	1 445
Cash/cash equivalents at 1st January	959	20
Cash/cash equivalents at 31st December	**20**	**1 465**

Cash flow statement	2016	2017
		27 053
		6 088
		250
working capital and provisions	28 980	33 391
(Increase) in net current assets	840	1 661
Additional cash contribution to reduce deficits (e.g. pension deficit)	1 400	1 600
Increase/(decrease) provision	648	634
Cash generated from operations	**27 388**	**29 496**
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Cash flows from investing activities are associated with the purchase and sale of non-current assets, such as property, plant and equipment and the income of investments held by the company. Acquisition consists of net of cash or debt acquired.

Cash flow statement	2016	2017
Net cash flows from operating activities	**19 972**	**21 049**
Cash flows from investing activities		
Proceeds from disposal of plant	98	135
Purchase of property, plant and equipment	5 742	6 539
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Cash flow statement	2016	2017
Cash flows from operating activities		
Profit before tax and finance cost	23 311	27 053
Depreciation and amortisation	5 489	6 088
Loss on disposal of plant	180	250
Operating cash flows before changes in	28 980	33 391
		1 661
		1 600
		634
Cash generated from operations	**27 388**	**29 496**
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Cash flows from financing activities are connected to the long-term financing of the company. This includes dividends paid out to those who have equity in the holding (parent) company, as well as debt financing (new bank loans or repayment on old ones).

Cash flow statement	2016	2017
Net cash flows from operating activities	**19 972**	**21 049**
Cash flows from investing activities		
Proceeds from disposal of plant	98	135
Purchase of property, plant and equipment	5 742	6 539
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I		634
C		29 496
Interest paid	1 404	1 049
Interest received	1	1
Income tax paid	6 013	7 399

Net increase (or decrease) in cash and cash equivalents shows the effect of the aforementioned cash flows over a given period.

Cash flow statement	2016	2017
Net cash flows from operating activities	**19 972**	**21 049**
Cash flows from investing activities		
Proceeds from disposal of plant	98	135
Purchase of property, plant and equipment	5 742	6 539
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Costing R&D phase

Some common cost:

- **Employee costs** (This relates to employing staff directly who are actively engaged in carrying out R&D itself)
- **Utilities** (Power, water, fuel used directly in carrying out R&D)
- **Software** (Computer software used directly in the R&D)
- **Capital expenditure** (expenditure by a business on acquiring or maintaining fixed assets (e.g. land, buildings and equipment))
- **Payments to clinical trials volunteers** (or other clinical validation cost)
- **Materials** (Consumable or transformable materials used directly in carrying out R&D)

Source www.gov.uk

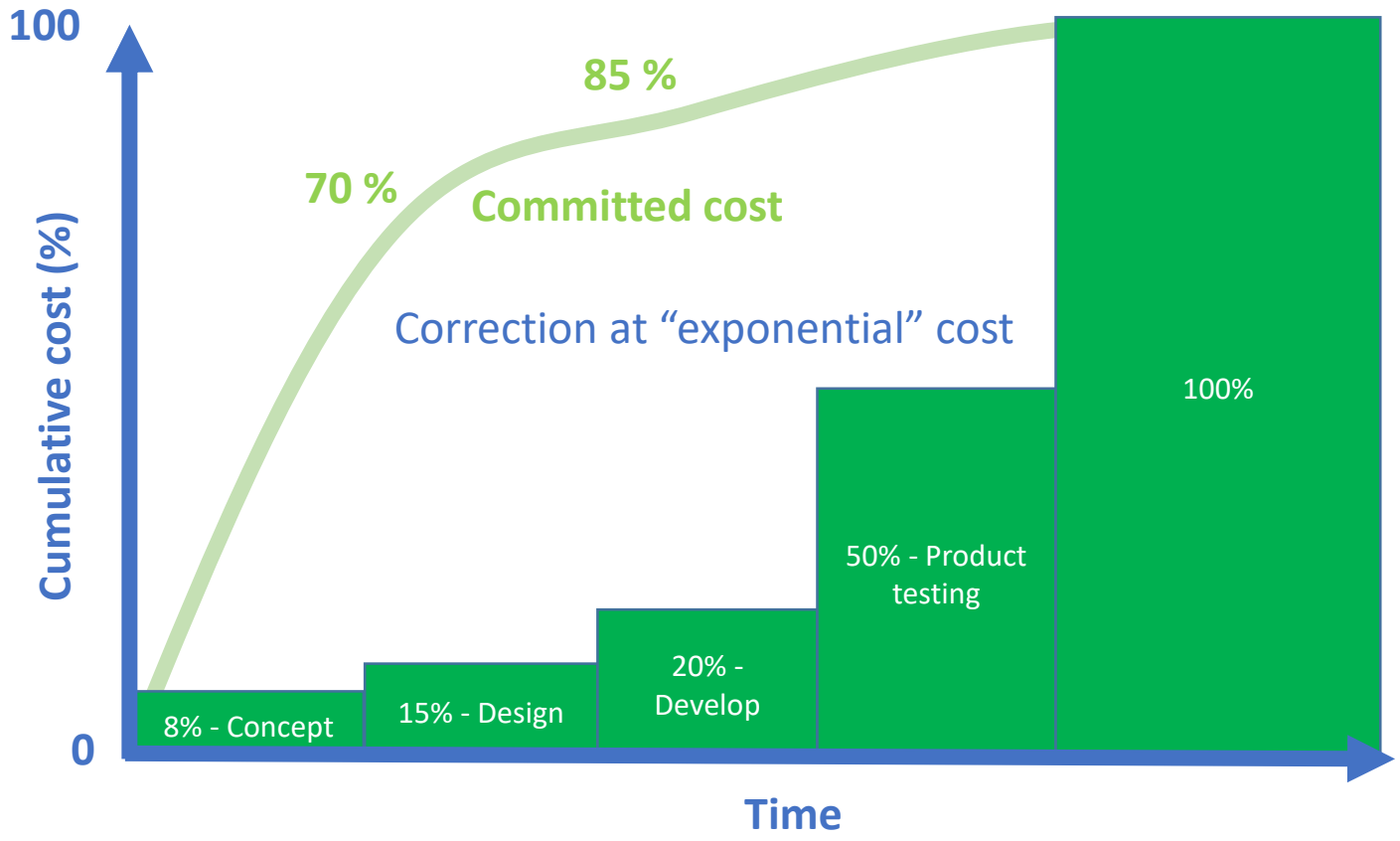
Product cost

Setup a bill of material (**BOM**), which lists all the materials, and parts it takes to making your product. Include part name, description, quantity used in the product, dimensions and weights, and the material it is made of.

It is widely recognised that **over 70% of the final product costs are determined during design** (Boothroyd, Dewhurst & Knight 2011: 7),

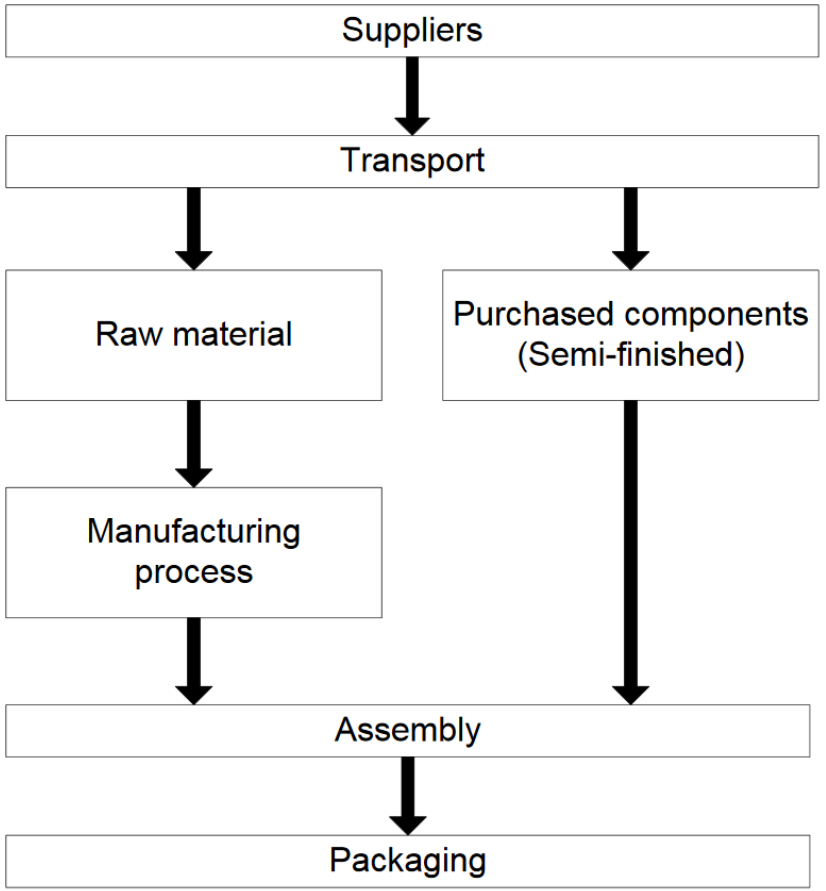
Product Cost= Material Cost + Assembly labour cost + Overheads
Material cost =parts, scrap, maybe amortized tooling to make parts.
Assembly labour = manufacturing, assembly, testing, packaging.

Committed life cycle cost against time



Source: INCOSE Systems Engineering Handbook, version 3 .

Production cost



Source: P Asking (2011)

VAT

Rate	% of VAT	What the rate applies to
Standard	20%	Most goods and services
Reduced rate	5%	Some goods and services, eg children's car seats and home energy
Zero rate	0%	Zero-rated goods and services, eg most food and children's clothes

Exempt from VAT see https://www.gov.uk/guidance/rates-of-vat-on-different-goods-and-services

Operating cycle

$$Number\ of\ days\ of\ inventory = \frac{Inventory}{Average\ day's\ cost\ of\ goods\ sold}$$

$$Number\ of\ days\ of\ receivables = \frac{Accounts\ receivable}{Average\ day's\ sales\ on\ credit}$$

$$Number\ of\ days\ of\ payables = \frac{Accounts\ payable}{Average\ day's\ purchases}$$

$$Operating\ cycle = Number\ of\ days\ of\ inventory + Number\ of\ days\ of\ receivables$$

$$Net\ operating\ cycle = Number\ of\ days\ of\ inventory + Number\ of\ days\ of\ receivables\ - Number\ of\ days\ of\ purchases$$

Liquidity

$$Current\ ratio = \frac{Current\ assets}{Current\ liabilities}$$

$$Quick\ ratio = \frac{Current\ assets\ - Inventory}{Current\ liabilities}$$

$$Net\ working\ capital\ to\ sales\ ratio = \frac{Current\ assets\ - Current\ liabilities}{Sales}$$

Profitability

$$Gross\ profit\ margin = \frac{Gross\ income}{Sales}$$

$$Oprating\ profit\ margin = \frac{Operating\ income}{Sales}$$

$$Net\ profit\ margin = \frac{Net\ income}{Sales}$$

Activity

$$Earning\ per\ share = \frac{Net\ income\ available\ to\ shareholders}{Number\ of\ shares\ outstanding}$$

$$Dividends\ per\ share = \frac{Dividends\ paid\ to\ shareholders}{Number\ of\ shares\ outstanding}$$

$$Dividend\ payout\ ratio = \frac{Dividends}{Earnings}$$

$$Price\ earnings\ ratio = \frac{Market\ price\ per\ share}{Earnings\ per\ share}$$

$$Inventory\ turnover = \frac{Cost\ of\ goods\ sold}{Inventory}$$

$$Accounts\ receivable\ turnover = \frac{Sales\ on\ credit}{Accounts\ receivable}$$

$$Total\ asset\ turnover = \frac{Sales}{Total\ assests}$$

$$Fixed\ asset\ turnover = \frac{Sales}{Fixed\ assests}$$

Financial Leverage

$$Total\ debt\ assests\ ratio = \frac{Total\ debt}{Total\ assets}$$

$$Long\ term\ \ debt\ to\ assests\ ratio = \frac{Long\ term\ debt}{Total\ assets}$$

$$Total\ \ debt\ to\ equity\ ratio = \frac{Total\ debt}{Total\ shareholders'equity}$$

$$Equity\ multplier = \frac{Total\ assets}{Total\ shareholders'equity}$$

$$Times\ interest\ coverage\ ratio = \frac{Earnings\ before\ interest\ and\ taxes}{Interest}$$

$$Fixed\ charge\ coverage\ ratio = \frac{Earnings\ before\ interest\ and\ taxes + Lease\ payment}{Interest + Lease\ payment}$$

Shareholder and return ratios

$$Earnigs\ per\ share = \frac{Net\ income\ available\ to\ shareholders}{Number\ of\ shares\ outstanding}$$

$$Dividends\ per\ share = \frac{Dividends\ paid\ to\ shareholders}{Number\ of\ shares\ outstanding}$$

$$Dividend\ payout\ ratio = \frac{Dividends}{Earnings}$$

$$Price\ earnings\ ratio = \frac{Market\ price\ per\ share}{Earnings\ per\ share}$$

$$Basic\ earning\ power\ ratio = \frac{Operating\ income}{Total\ asset}$$

$$Return\ on\ assets = \frac{Net\ income}{Total\ asset}$$

$$Return\ on\ equity = \frac{Net\ income}{Shareholder's\ equity}$$

Source: Professor Pamela Peterson Drake

Company types

The main types are:

- **Sole trader**, you are personally responsible for any loses that you make.
- **Limited company**, it's responsible in its own right for everything it does and its finances are separate to your personal finances. Every limited company has 'members', the people or organisations who own shares in the company. Directors are responsible for running the company. Directors often own shares, but they don't have to.
- **Business partnership,** you and your business partner (or partners) personally share responsibility for your business.

An 'unincorporated association' is for a small organisation, which does not want to make a profit.

You also have 'social enterprises', which aims to help people or communities.

Source: Gov.uk

Standard industrial classification of economic activities (SIC)

- A condensed list of SIC codes for providing Companies House with a description of your company's nature of business can be found at:

www.gov.uk/government/publications/standard-industrial-classification-of-economic-activities-sic

- Apply the code that best describes your company

Questions?

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Management Practice

5. People & Project management

6. Statistics in management

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

27/10/2020

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to mention key factors that influence management success
- Able to compute and critically a Pearson Correlation

Literature for this session:

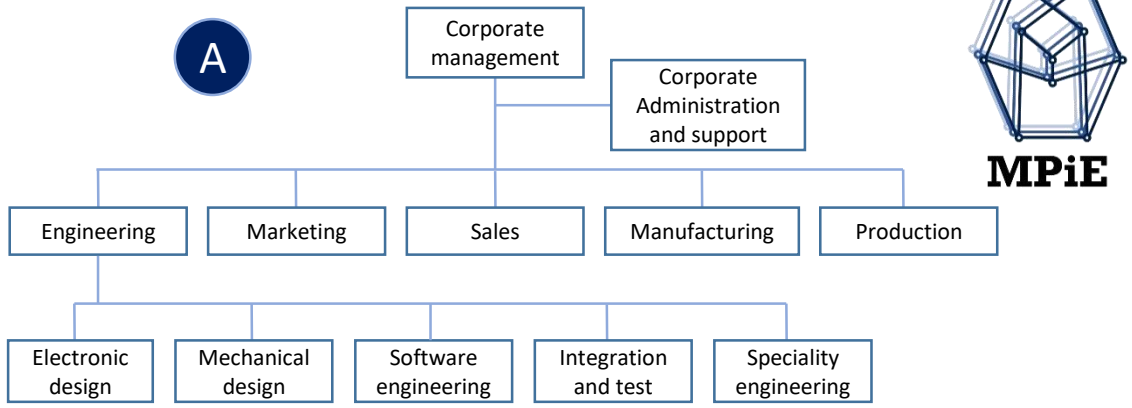
Zou, Kelly H., Kemal Tuncali, and Stuart G. Silverman. "Correlation and simple linear regression." *Radiology* 227.3 (2003): 617-628.

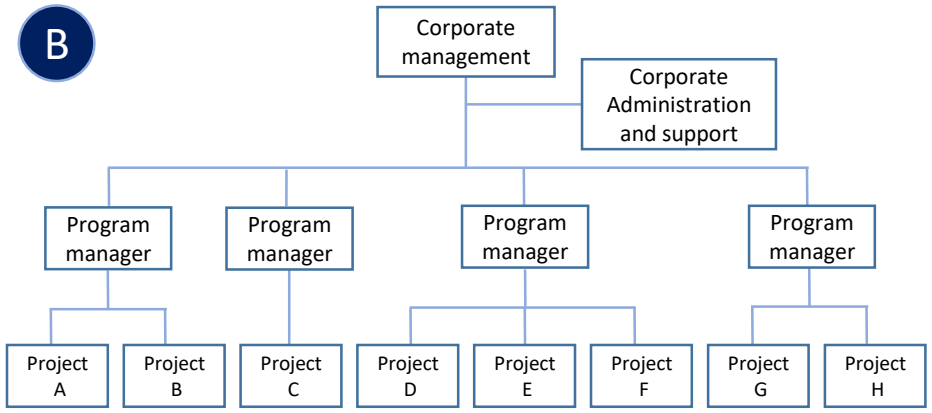
Hoaglin, David C., and Roy E. Welsch. "The hat matrix in regression and ANOVA." *The American Statistician* 32.1 (1978): 17-22.

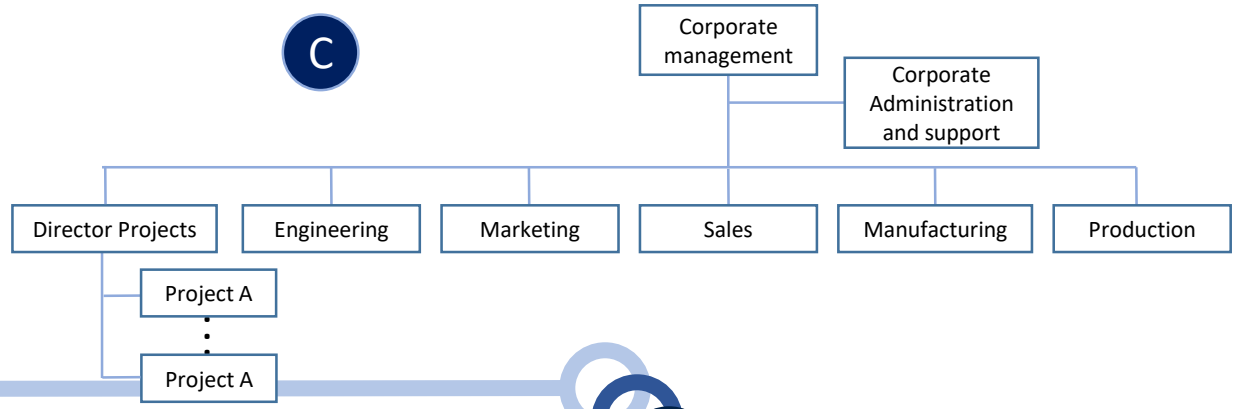
Cooke-Davies, Terry. "The ‘‘real’’success factors on projects." *International Journal of Project Management* 20 (2002): 185-190.

Cooperate organisations

- **Functional structure**, functional areas defined as e.g. engineering, marketing, sales, etc.
- **Project structure**, entire organization consists of a set of projects. Applicable in service industry reliant on external project calls.
- **Matrix structure**, a hybrid between functional and project structure. Internal competition between project and functional groups.
- People are managed within these structures.







Source: Eisner, Essentials of project and systems engineering management, 2008

Manager – simple view

Managing people is one of the most important leadership skills as it influences productivity through staff morale.

Take away message: There is a difference

Figure 1: Comparison of Management and Leadership Process Differences in the Workplace

Process	Management	Leadership
Vision Establishment	• Plans and budgets • Develops process steps and sets timelines • Displays impersonal attitude about the vision and goals	• Sets the direction and develops the vision • Develops strategic plans to achieve the vision • Displays very passionate attitude about the vision and goals
Human Development and Networking	• Organizes and staffs • Maintains structure • Delegates responsibility • Delegates authority • Implements the vision • Establishes policy and procedures to implement vision • Displays low emotion • Limits employee choices	• Aligns organization • Communicates the vision, mission, and direction • Influences creation of coalitions, teams, and partnerships that understand and accept the vision • Displays driven, high emotion • Increases choices
Vision Execution	• Controls processes • Identifies problems • Solves problems • Monitors results • Takes low-risk approach to problem solving	• Motivates and inspires • Energizes employees to overcome barriers to change • Satisfies basic human needs • Takes high-risk approach to problem solving
Vision Outcome	• Manages vision order and predictability • Provides expected results consistently to leadership and other stakeholders	• Promotes useful and dramatic changes, such as new products or approaches to improving labor relations

Source: Kotterman (2006) *The Journal for Quality and Participation* 29.2

Project

- “A project is **temporary** in that it has a defined beginning and end in time, and therefore defined scope and resources.”
- “[A] project is **unique** in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. So a project team [could] include people who don’t usually work together – sometimes from different organizations and across multiple geographies.”
- **Project management**, then, is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

Source: PMI

Project management

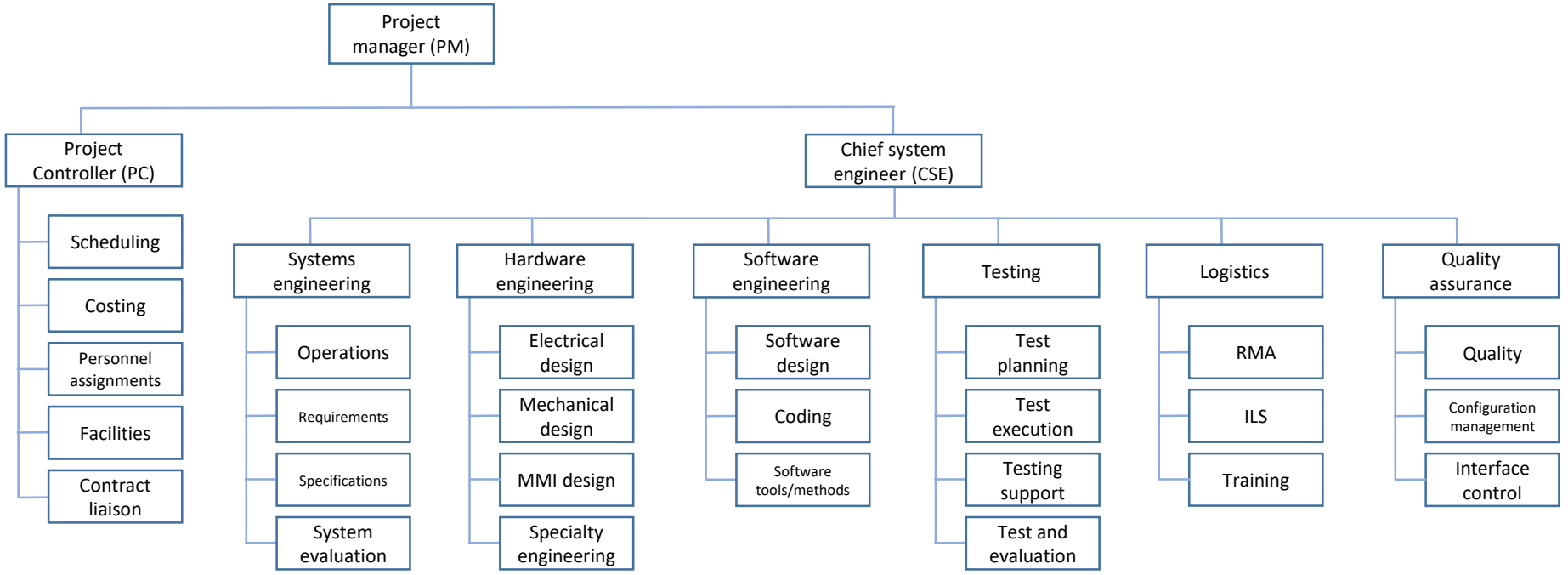
Project problems often occur in terms of:

1. Schedule (time)
2. Cost (as compared with the original budget)
3. Performance and quality

Project management thus means you make sure you are on time, budget and in scope as well as on spec.

Source: Eisner, Essentials of project and systems engineering management, 2008

Project management



RMA = reliability-maintainability-availability
ILS = integrated logistics support
MMI = man-machine interface

Source: Eisner, Essentials of project and systems engineering management, 2008

Project management success

- Project success = measured against the overall objectives of the project

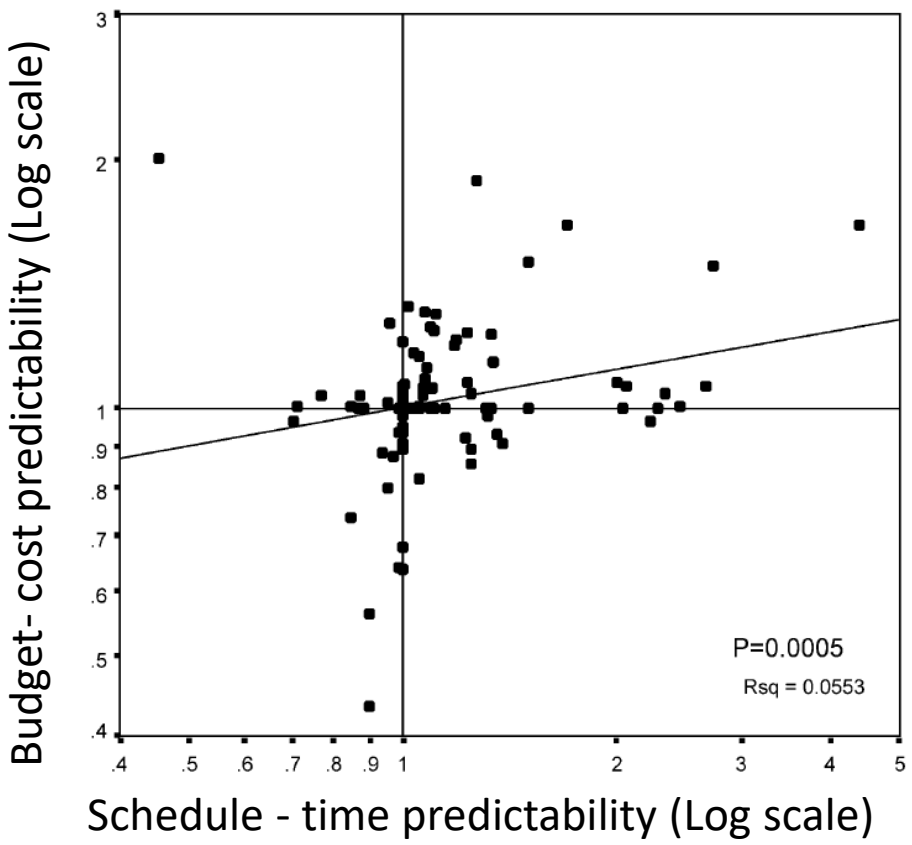
- Project success cannot be measured until after the project is completed, whilst project performance can be measured during the life of the project

- Project management success = measured against the widespread and traditional measures of performance against cost, time and quality

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Project management success

- Each point on the graph represents one of the projects and its performance against schedule (on the x axis) and budget (on the y axis).
- Mean performance against budget (cost escalation) is generally better than mean performance against schedule (lateness)



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

r – Pearson correlation coefficient

- Pearson correlation coefficient is applicable to interval or continuous (scale/interval) data.

- Pearson correlation is a parametric test (it makes assumptions about the parameters of the underlying population distribution).

- The Spearman correlation coefficient can be based on continuous data and it measures the monotonic relationship between two variables (scale/interval or ordinal data).

Source: Zou, Kelly et al , 2003

Spearman’s rank correlation coefficient

The Spearman's rank correlation coefficient can be seen in a simple way as a non-parametric version of the Pearson product-moment correlation

$$r_{spear} = 1 - \frac{6\left(\sum_{i=1}^{n} d_i^2\right)}{n(n^2 - 1)}$$

d is the difference between two ranks and *n* is number of pairs of data

low to high	
x rank	y rank
1	1
2	4.5
3	6
4	2
5	4.5
6	3

Note: When 2 values (or more) are tied with the same rank, you must give them the same rank number which must be the average between the tied ranks

Note: Kendall’s other rank correlation

r – Pearson correlation coefficient

Population

$$\rho_{X,Y} = \frac{Cov(X,Y)}{\sigma_x \sigma_Y}$$

$$Cov(X,Y) = E[(X - \mu_x)(Y - \mu_Y)]$$

$$Cov(X,Y) = covariance$$

$$\mu = mean$$

$$\sigma = standard\ deviation$$

$$\rho = population\ correlation$$

Sample

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\,(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

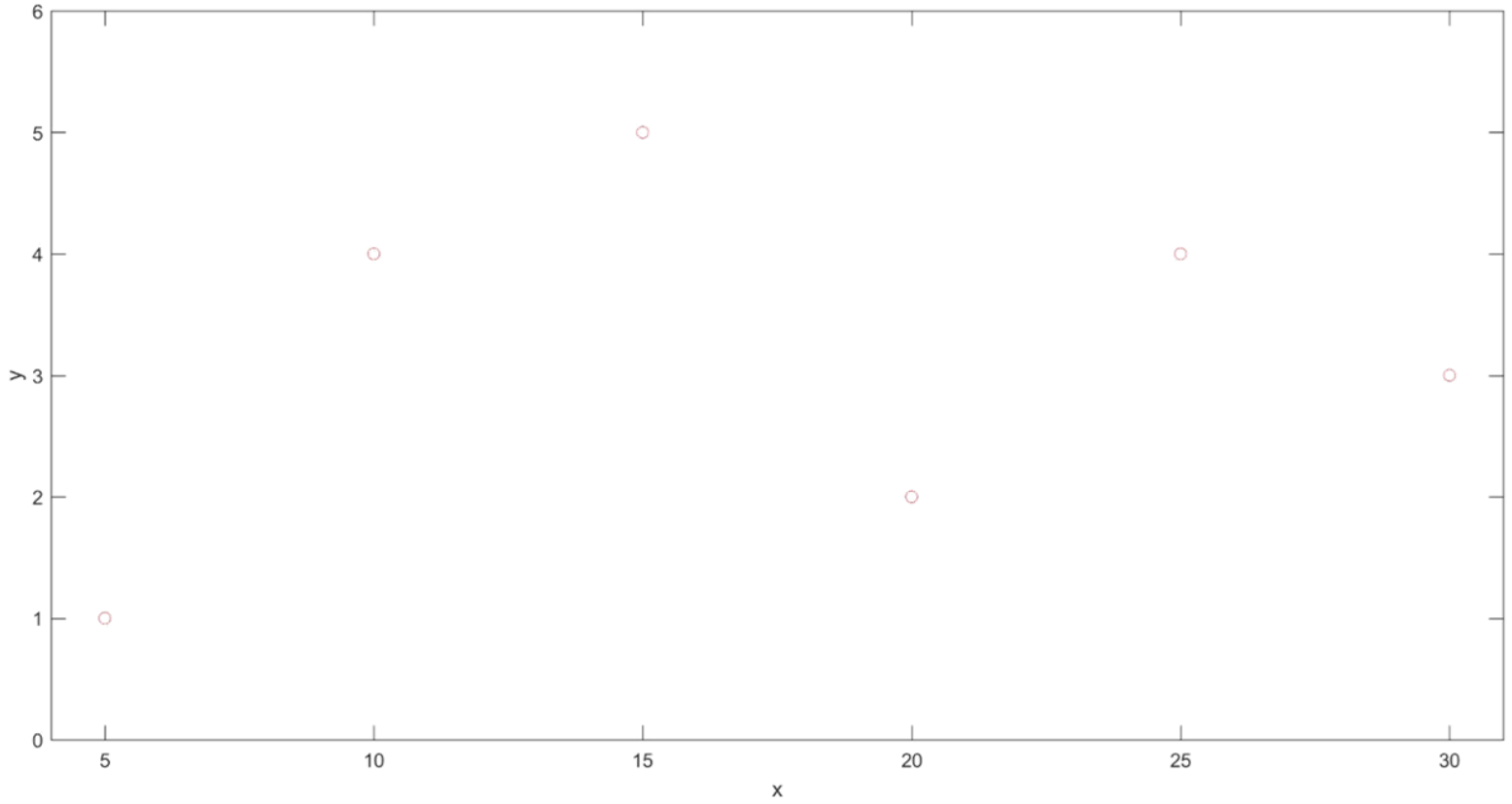
$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \ \ same\ for\ \bar{y}$$

Properties of *r*

- *r* is a number between -1 and 1
- *r(X,Y)=r(Y,X)*
- *r = 1* or *r = -1* indicates a perfect correlation
- *r > 0* indicates positive association
- *r < 0* indicates negative association

Calculating *r*

x (A.U.)	y (A.U.)
5	1
10	4
15	5
20	2
25	4
30	3



$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} = .2542$$

Ratio of the **co-variability** (numerator) of x and y to the **variability** (denominator) of x and y independently

Anscombe's Quartet

Correlation

$r = .67$

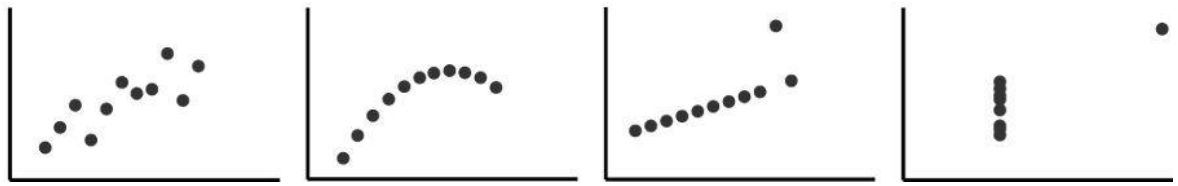
Linear regression

$y = 3 + .5x$

a

I		II		III		IV	
x	*y*	*x*	*y*	*x*	*y*	*x*	*y*
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.10	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.10	4	5.39	19	12.5
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

b



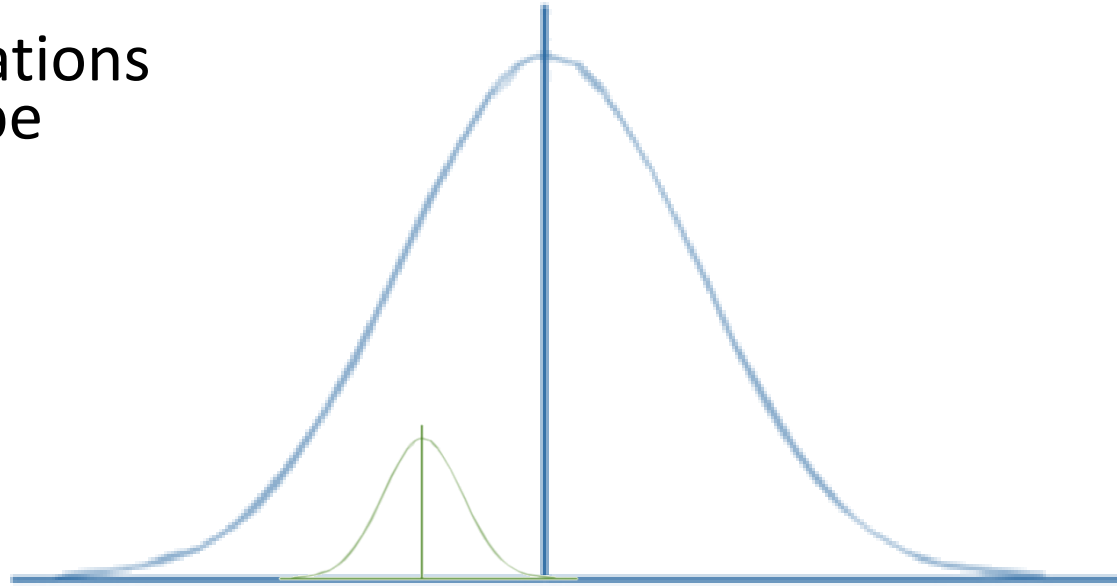
Source: Shoresh & Wong, Nature methods, 2012

Statistical hypothesis testing *r*

- The value *r* indicates the strength of a linear relationship in **samples** only. Thus, for a different sample a different value can be obtained.

- The aim is to draw conclusions over populations not samples, so a confidence interval can be calculated or a hypothesis test can be conducted.

- A hypothesis test can be conducted for the population correlation coefficient ρ.



Statistical hypothesis testing for *r*

- The null hypothesis (H_0) states that there is no correlation between *x* and *y* variables in the population.
- The alternative hypothesis (H_1) states that there is a correlation between *x* and *y* variables in the population.

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

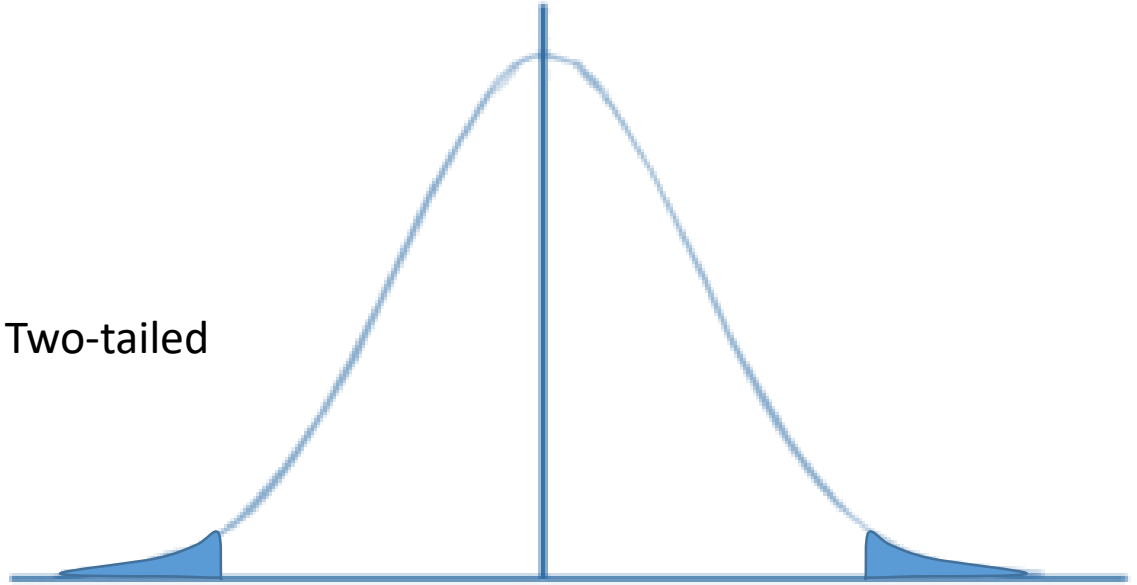
- A *t*-test (*df: n-2* ∵ *pairs*) for the correlation coefficient can be performed to test the hypothesis.
- Increasing *t*-values (with fixed *df*) indicates higher probability of H_1 being correct.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Calculating t

x (A.U.)	y (A.U.)
5	1
10	4
15	5
20	2
25	4
30	3

Two-tailed



$$t = r\sqrt{\frac{n-2}{1-r^2}} = 0.5257$$

$$p = .6269 > \alpha = .05$$

$$Upper\ 95\%\ CI = .6269$$

$$Lower\ 95\%\ CI = -.7022$$

Different ways of calculating the subsequent p-value using e.g. Simpson's Rule,
Monte Carlo Integration or NBS Approximation.

The formula or a look-up table can be used from HLT

Linear regression

Objective is to minimise the distances between data points and model (line)

$$y = mx + b$$

Set up a loss function *L*, with $\hat{y}$ being the estimated value of our model

$$L(\hat{y}, y) = \frac{1}{2}(\hat{y} - y)^2$$

Sum of squared distances is Sum of Squares (*S*) - [no need for $\frac{1}{2}$]

$$S = \sum_{i=1}^{n}\left((mx_i + b) - y_i\right)^2 = \sum_{i=1}^{n}(\hat{y}_i - y_i)^2 = \sum_{i=1}^{n} d_i^2$$

$$\therefore S = \sum_{i=1}^{n}(mx_i + b)^2 - 2(mx_i + b)y_i + y_i^2 = \sum_{i=1}^{n}\left(m^2x_i^2 + 2bmx_i + b^2\right) - 2mx_iy_i - 2by_i + y_i^2$$

Minimise sum based on parameter *m* and *b* by applying partial derivatives

Linear regression

For

$$S = \sum_{i=1}^{n} \left(m^2 x_i^2 + 2bmx_i + b^2\right) - 2mx_i y_i - 2by_i + y_i^2$$

$$\frac{\partial S}{\partial b} = \sum_{i=1}^{n} (2mx_i + 2b - 2y_i)$$

Set

$$\frac{\partial S}{\partial b} = 0$$

Divide both sides by 2

$$m\left(\sum_{i=1}^{n} x_i\right) + \left(\sum_{i=1}^{n} b\right) - \left(\sum_{i=1}^{n} y_i\right) = 0 \qquad \rightarrow nm\bar{x} + nb - n\bar{y} = 0 \rightarrow \boxed{\bar{y}=m\bar{x} + b}$$

Linear regression

For

$$S = \sum_{i=1}^{n} \left(m^2 x_i^2 + 2bmx_i + b^2\right) - 2mx_i y_i - 2by_i + y_i^2$$

$$\frac{\partial S}{\partial m} = \sum_{i=1}^{n} \left(2mx_i^2 + 2bx_i - 2x_i y_i\right)$$

Set

$$\frac{\partial S}{\partial m} = 0$$

Divide both sides by 2

$$\mathrm{m}\left(\sum_{i=1}^{n} x_i^2\right) + b\left(\sum_{i=1}^{n} x_i\right) - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \qquad \rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + bn\bar{x} - n\left(\sum_{i=1}^{n} x_i y_i\right) = 0$$

Linear regression

From the previous slide $\frac{\partial S}{\partial b}$

$$\bar{y} = m\bar{x} + b \rightarrow b = \bar{y} - m\bar{x}$$

$$m\left(\sum_{i=1}^{n} x_i^2\right) + bn\bar{x} - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + (\bar{y} - m\bar{x})n\bar{x} - \left(\sum_{i=1}^{n} x_i y_i\right) = 0$$

$$\rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + n\bar{x}\bar{y} - mn\bar{x}^2 - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \rightarrow m\left[\left(\sum_{i=1}^{n} x_i^2\right) - n\bar{x}^2\right] = \left(\sum_{i=1}^{n} x_i y_i\right) - n\bar{x}\bar{y}$$

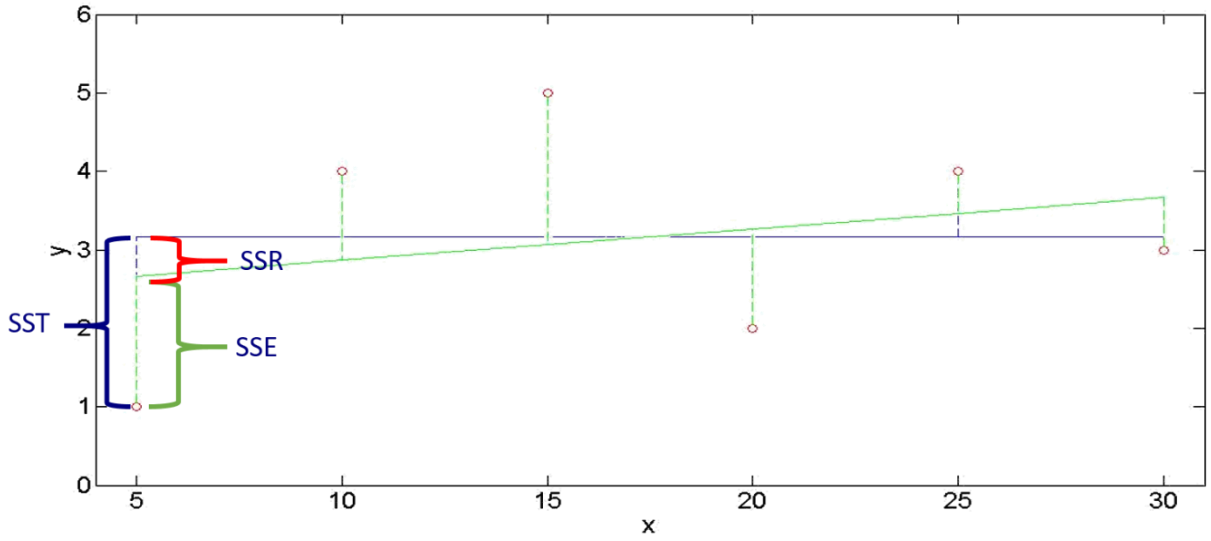
$$m = \frac{\left(\sum_{i=1}^{n} x_i y_i\right) - n\bar{x}\bar{y}}{\left(\sum_{i=1}^{n} x_i^2\right) - n\bar{x}^2} = \frac{s_{xy}}{s_{xx}} \qquad \frac{"Covaraiance\ x, y"}{"Variance\ x"}$$

R^2 – coefficient of determination

- R^2 is a measure that provides information about the goodness of fit for a (linear) model.

$$R^2 = \frac{sum\ squared\ regression\ (SSR)}{total\ sum\ of\ squares\ (SST)} = 1 - \frac{sum\ squared\ errors\ (SSE)}{total\ sum\ of\ squares\ (SST)} = 1 - \frac{\sum(y_i - \hat{y})^2}{\sum(y_i - \bar{y})^2}$$

$$SST = SSR + SSE$$



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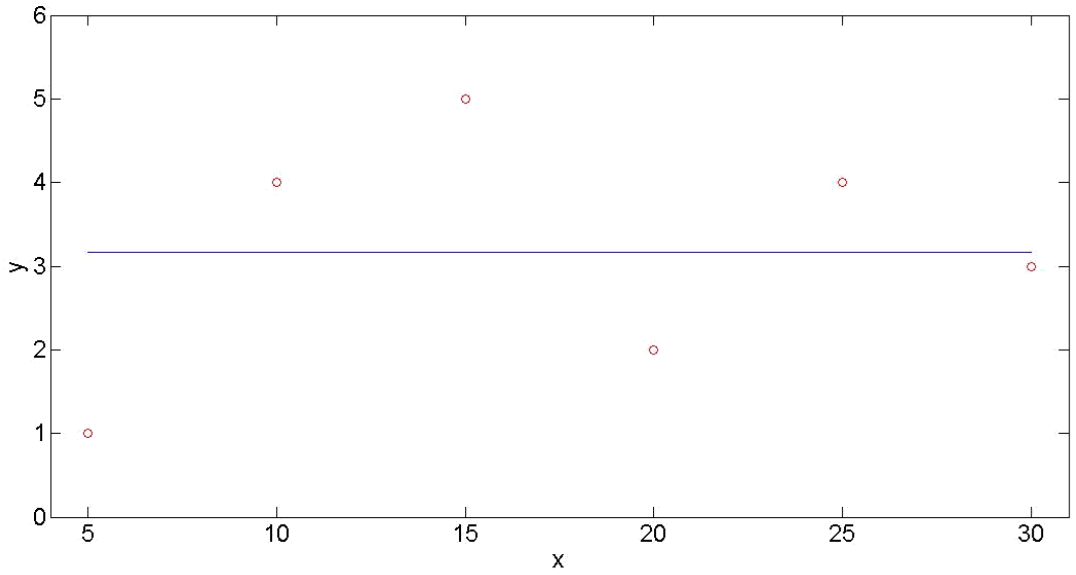

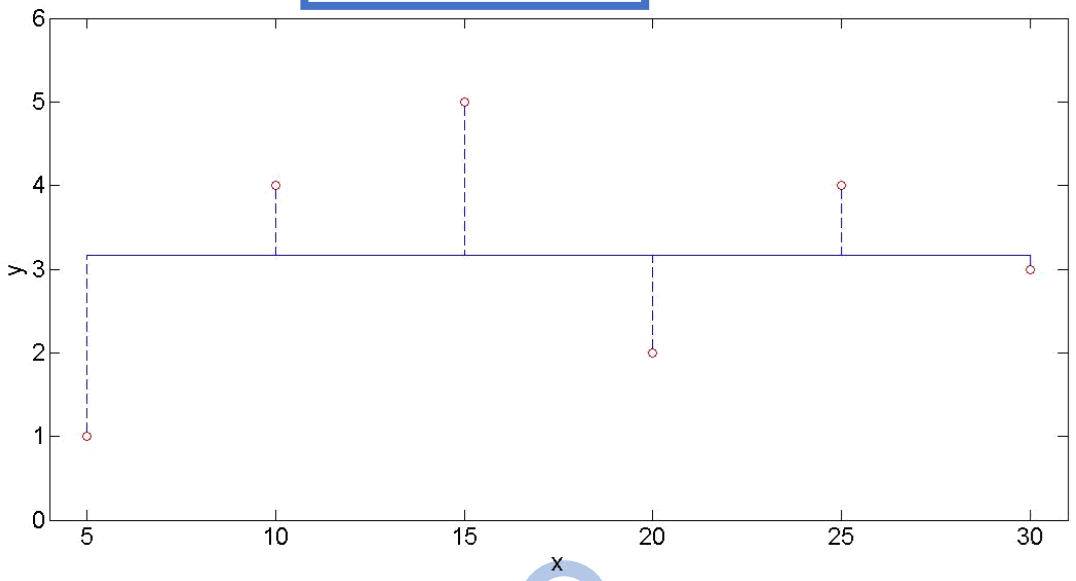

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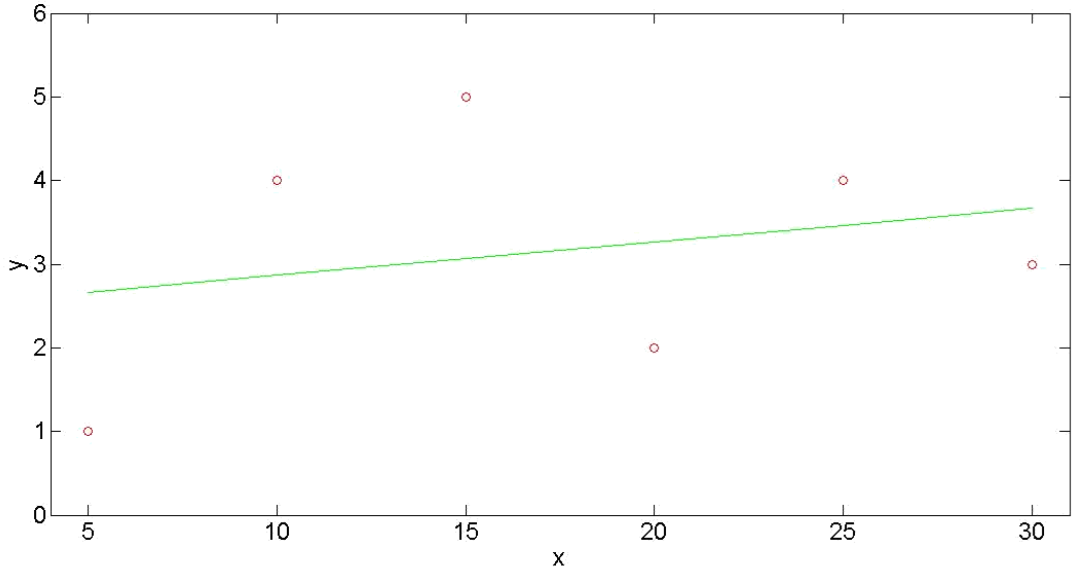
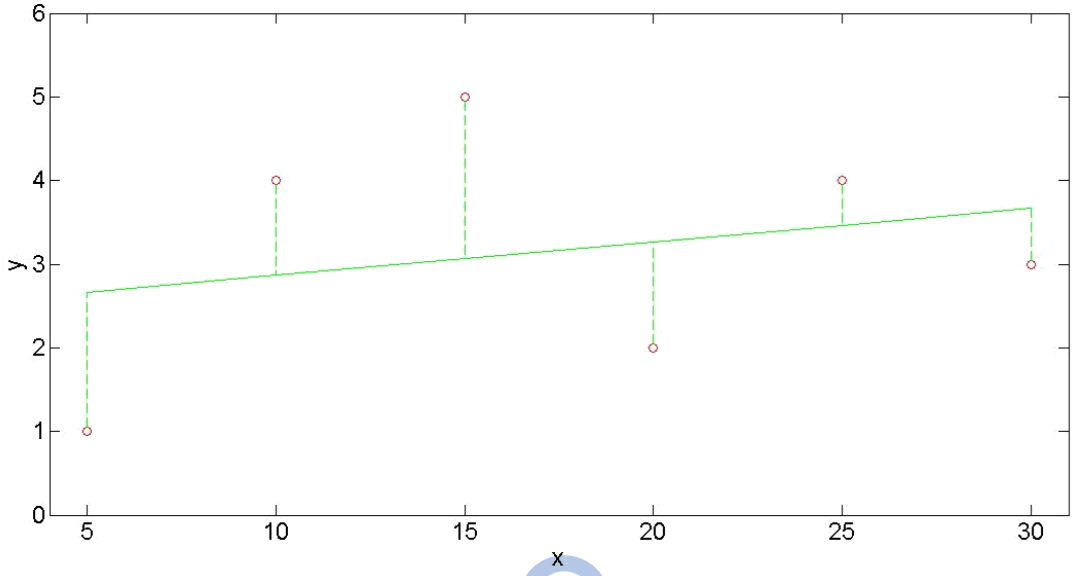




R^2 – coefficient of determination

- R^2 compares the errors of your regression model to the errors of a model based on the mean of *y*.

- It provides a fraction of unexplained variance since it compares the unexplained variance (variance of the model's errors) with the total variance (of the data).

- There is an assumption of linearity

Multiple regression model for prediction

A multiple linear regression model with *k* predictor variables v_1, v_2, ..., v_k
and a response y , can be written as

$$y = \beta_0 + \beta_1 v_1 + \cdots \beta_k v_k + \epsilon$$

with ϵ being the residual term(s) of the model and$\beta_0 \ \cdots \beta_k$ are the regression coefficients (higher powers can be included in more complex models)

The model can also include interaction effects of two or more variables

$$y = \beta_0 + \beta_1 v_1 + \beta_{12} v_1 v_2 \cdots \beta_k v_k + \epsilon$$

Any model with a linear combinations of β parameters can be seen as a linear model.

R^2 – multiple regression

- Overfitting can occur if the too many independent variables (predictors) are included, as it begins to model random noise in the data. It can lead to the creation of higher order polynomials.

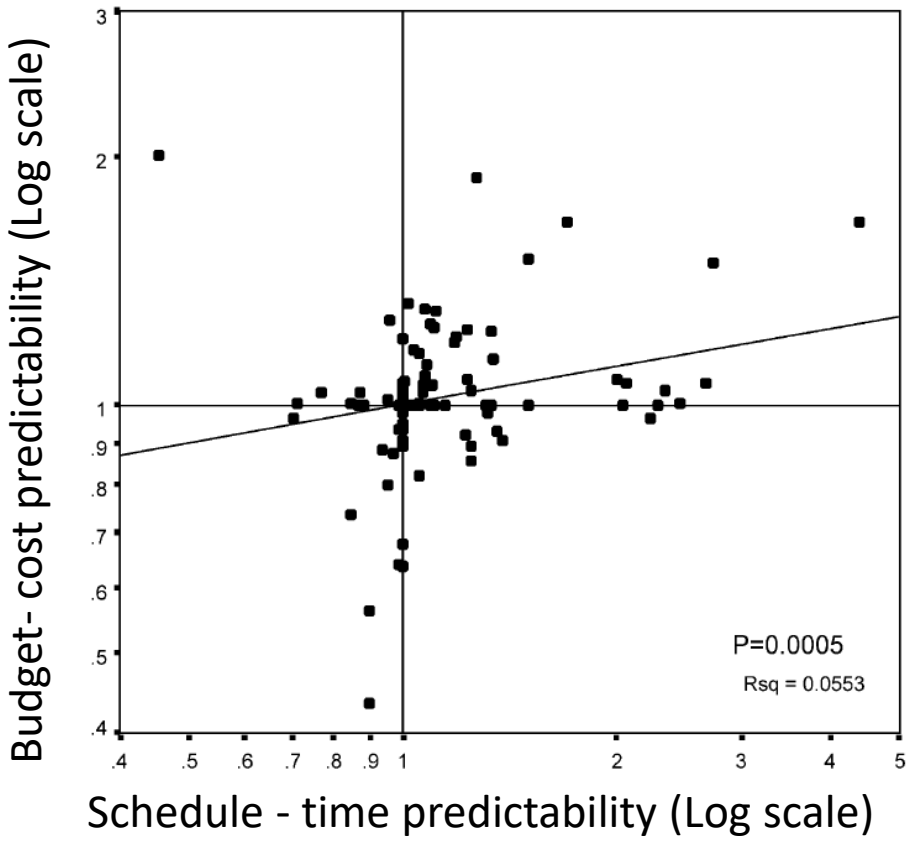
- The adjusted R^2 has been adjusted for the number of predictors in the model.

$$R^2_{adj} = 1 - \frac{SSR/n-(k+1)}{SST/n-1}$$

n= sample size; *k*=number of independent variables

Project management success

- There is a low R^2 value indicating that ~6% of the of the variance in the budget variable is predictable from the schedule variable.
- Budget and time predictability have a weak connection.



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect on-cost performance

- Allowing changes “to scope” only through a mature scope change control process.

- Maintain the integrity of the performance measurement baseline.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

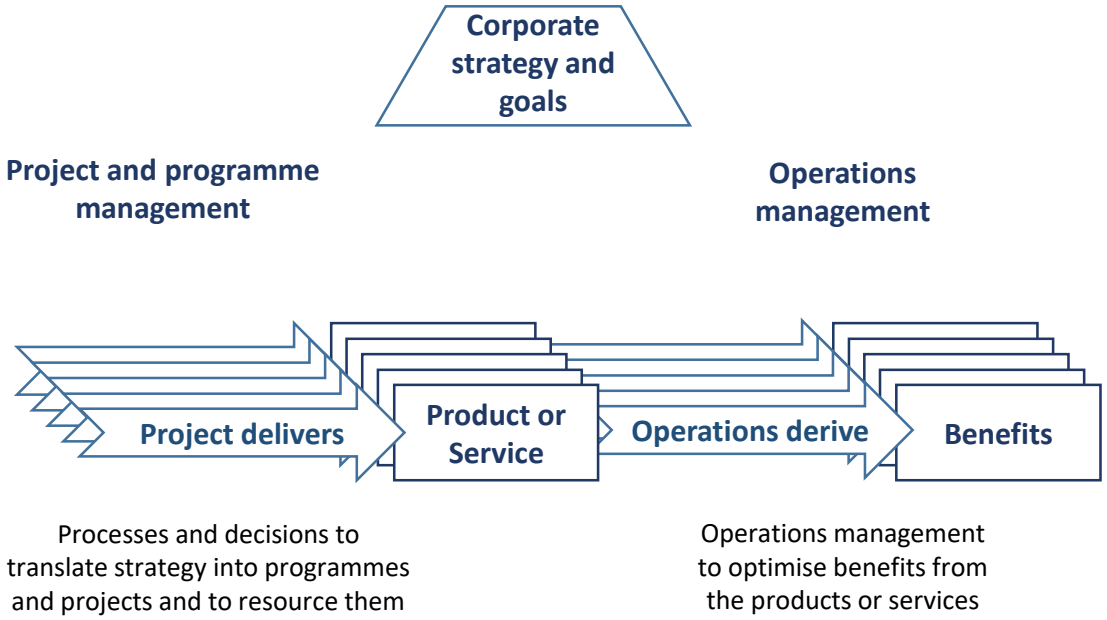
Factors that effect on-time performance

- Adequacy of company-wide education on the concepts of risk management.
- Maturity of an organisation's processes for assigning ownership of risks.
- Adequacy with which a visible risk register is maintained.
- Adequacy of an up-to-date risk management plan.
- Adequacy of documentation of organisational responsibilities on the project.
- Keep project (or project stage duration) as far below 3 years as possible (1 year is better).

Source: Cooke-Davies, The ''real'' success factors on projects, 2002

Factors to success on individual projects

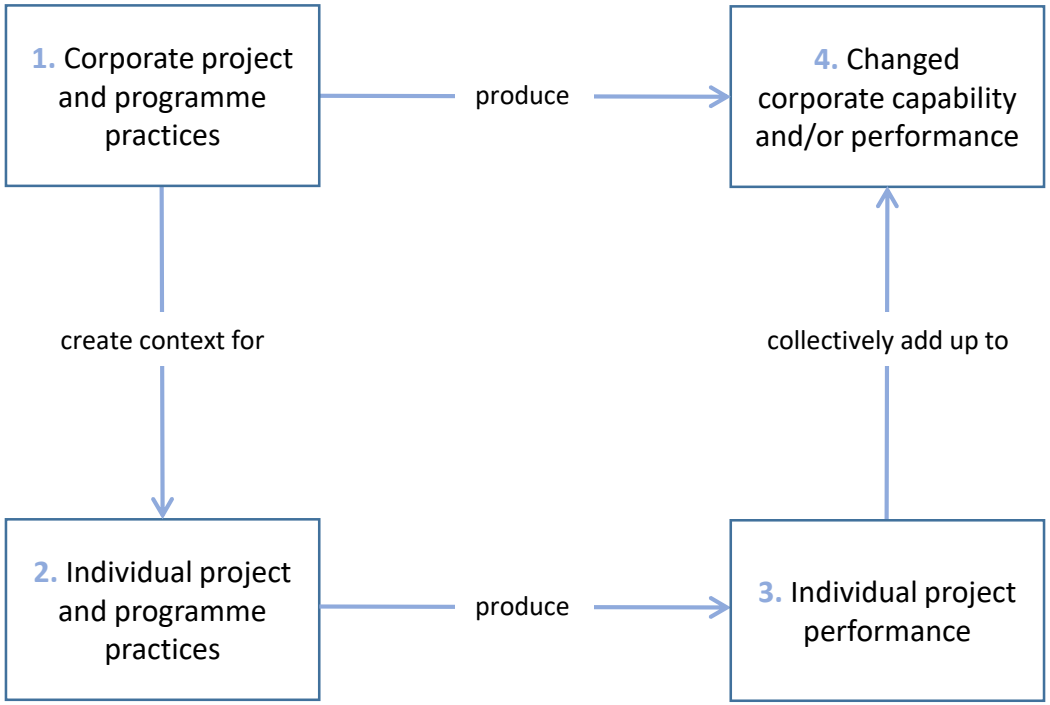
- Project success ≠ project management success.
- It requires the existence of an effective benefits delivery and management process that involves the mutual co-operation of project management and line management functions.
- The benefits are what the stakeholder hoped to achieve through the project



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect corporate project success

Schematic context representation



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect corporate project success

- Portfolio- and programme management practices that allow the enterprise to resource fully a suite of projects that are thoughtfully and dynamically **matched to the corporate strategy and business objectives**.

- A suite of project, programme and portfolio **metrics** that provides direct ‘‘line of sight’’ feedback on current project performance, and anticipated future success, so that project, portfolio and corporate decisions can be aligned.

- An effective means of ‘‘learning from experience’’ on projects, that combines explicit knowledge with **encouraging people to learn** and to embed that learning into **continuous improvement** of project management processes and practices.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

The human skills imperative

- People perform every process that is prescribed and it is people who ultimately determine the adequacy of the factors described.

- The ‘‘people’’ side of the success factors is therefore essential.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

People perspective

The New York Times — March 13, 2011

Google's Rules

To engineer better managers, Google pored over performance reviews, feedback surveys and award nominations, correlating words and phrases as only a data-driven company like it can do. Here is an edited list of the directives it produced — in order of importance — as well as a few management pitfalls it found.

Eight Good Behaviors

1. Be a good coach
- Provide specific, constructive feedback, balancing the negative and the positive.
- Have regular one-on-ones, presenting solutions to problems tailored to your employees' specific strengths.

2. Empower your team and don't micromanage
- Balance giving freedom to your employees, while still being available for advice. Make "stretch" assignments to help the team tackle big problems.

3. Express interest in team members' success and personal well-being
- Get to know your employees as people, with lives outside of work.
- Make new members of your team feel welcome and help ease their transition.

4. Don't be a sissy: Be productive and results-oriented
- Focus on what employees want the team to achieve and how they can help achieve it.
- Help the team prioritize work and use seniority to remove roadblocks.

5. Be a good communicator and listen to your team
- Communication is two-way: you both listen and share information.
- Hold all-hands meetings and be straightforward about the messages and goals of the team. Help the team connect the dots.
- Encourage open dialogue and listen to the issues and concerns of your employees.

6. Help your employees with career development

7. Have a clear vision and strategy for the team
- Even in the midst of turmoil, keep the team focused on goals and strategy.
- Involve the team in setting and evolving the team's vision and making progress toward it.

8. Have key technical skills so you can help advise the team
- Roll up your sleeves and conduct work side by side with the team, when needed.
- Understand the specific challenges of the work.

Three Pitfalls of Managers

1. Have trouble making a transition to the team
- Sometimes, fantastic individual contributors are promoted to managers without the necessary skills to lead people.
- People hired from outside the organization don't always understand the unique aspects of managing at Google.

2. Lack a consistent approach to performance management and career development
- Don't help employees understand how these work at Google and doesn't coach them on their options to develop and stretch.
- Not proactive, waits for the employee to come to them.

3. Spend too little time managing and communicating

Source: Google

People practice

- Research found an almost even split in top-rated internal best practices between technical and people practices.

- The people skills set that successful teams have included the formation of high-calibre project teams, stakeholder participation, effective team and external communication, customer satisfaction, conflict management, and staff management and motivation

Source: Loo, Working towards best practices in project management: a Canadian study, 2002; Loo, multi-level causal model for best practices in project management benchmarking, 2003

People practice

- The fact that humans, under the appropriate conditions, can expand their contributions tremendously is what distinguishes them from other resources.

- Management may create a climate for motivation by enriching jobs in the following way:

1. Removing some controls while retaining accountability
2. Increasing the accountability of individuals for their own work
3. Giving a person a complete, natural unit of work (module, division, area, etc.)
4. Granting additional authority to an employee in his activity; job freedom
5. Making periodic reports directly available to the worker himself rather than to his supervisor
6. Introducing new and more difficult tasks not previously handled
7. Assigning individuals specific or specialized tasks, enabling them to become experts.

Source: Murdick, Managing human resources in project management, 1976

MPiE

Questions?

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Management Practice

7 & 8 Leadership and teams

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

03/11/2020

Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Understand failure and success based on evidence
- Develop and understand the essential skills and abilities that are necessary to manage and lead people effectively for the benefit of the individual and teams using need-led methods.
- Apply tools to develop your leadership skills and style

Literature for this session:

https://www.nature.com/articles/s41586-019-1725-y

Leadership, failure and trust

- CEOs can improve the quality of strategic decisions that their management teams make by shaping a relational context of **trust** and facilitating **learning from failures**

- Psychological safety (a shared belief held by members of a team that the team is safe for interpersonal risk taking) can support leadership

- A psychological safe climate seems to facilitate learning from failures and it is suggested to be positively associated with unit performance

Source: Abraham Carmeli et a (2012); Edmondson, Amy (1999); Reuven Hirak (2012)

Failure

- About **75% of U.S. venture-backed start-ups fail** according to data from the Harvard Business School
- Failure defined as liquidation of all assets would indicate 30% to 40% of high potential start-ups fail
- Failure defined as not delivering the projected return on investment from VCs suggests that about 95% of start-ups fail
- Majority of companies "failed" if we define failure as not having an exit (acquisition, IPO or otherwise) that was enough to pay back all of their VCs' investment

Source: Shikhar Ghosh Wall Street Journal (2013)

Management and failure

- Roughly 70 businesses are created in the UK every hour, but within five years over half will have collapsed
- **Good management** is a better predictor of a firm's success than R&D spending, IT spending or how skilled their workforce is.
- Almost a third of the differences in productivity between and within countries is based on whether or not firms **consistently monitor and improve their processes, set and revise targets, and incentivise employees through merit-based hiring, firing and promotion procedures.**

Source: Office for National Statistics – Inter-Departmental Business Register

x1000

	Active	Births		Deaths	
	Count	Count	Rate (%)	Count	Rate (%)
2013	2,449	346	14.1	237	9.7
2014	2,551	350	13.7	246	9.7
2015	2,699	383	14.3	282	10.4
2016	2,834	414	14.6	281	9.9
2017	2,926	382	13.1	362	12.4
2018	2,940	381	12.9	336	11.4

Source: Philip Salter, Forbes (2019), Sam Dumitriu, Management matters (2019); BRIEFING PAPER Number 06152, 12 December 2018

Dynamics of failure for start-ups

- What might be the dynamics of failure?

- Success is defined as ventures that achieved initial public offering (IPO) or high-value mergers and acquisitions.

- Failure occurs when they **don’t obtain an exit within five years after their first investment by venture capital firms**.

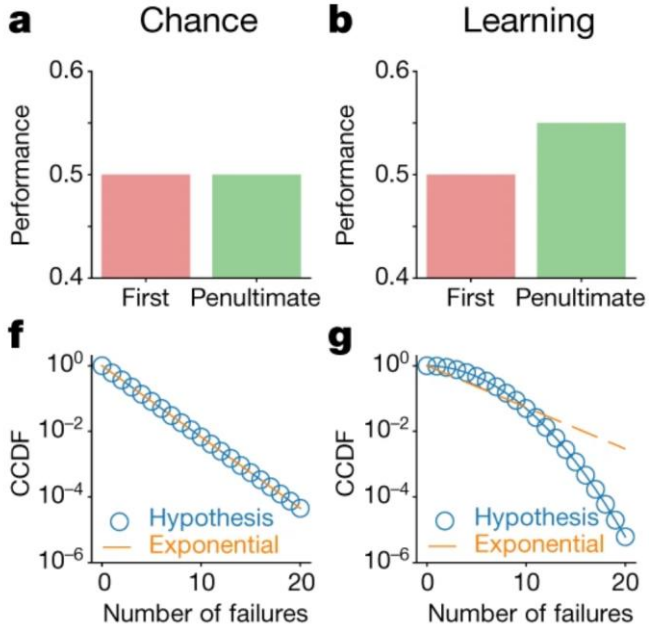
Source: Yin, Y., Wang, Y., Evans, J.A. *et al.* Quantifying the dynamics of failure across science, startups and security. *Nature* (2019)

Learning

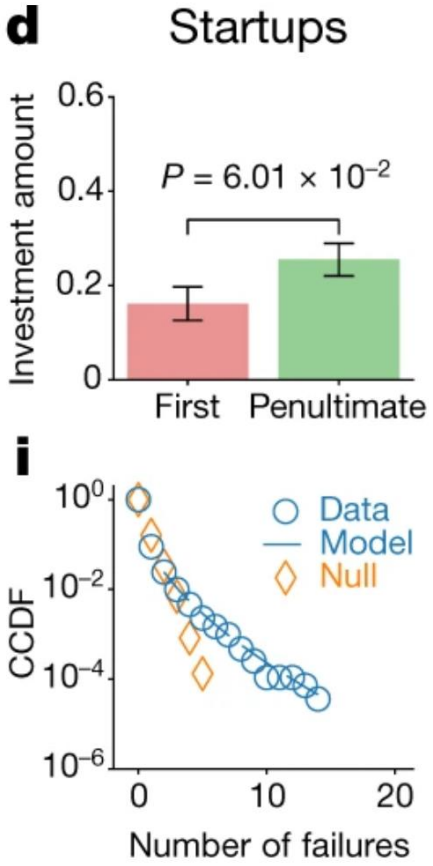
- Two primary mechanisms that could explain how failures may lead to success are **chance and learning**
- If each attempt has a certain likelihood of success, the probability that multiple attempts all lead to **failure to decrease exponentially** with each trial
- The chance model would suggest that success eventually arises from an **accumulation of independent trials**
- Data from start-up investment records from VentureXpert (58,111 start-up companies involving 253,579 innovators, 1970–2016) used to explore this

Source: Sitkin, S. B. Learning through failure: the strategy of small losses (1992) & Huber, G. Organizational learning: the contributing processes and the literatures (1991).

Learning from failure



Chance or learning alone can't explain the empirical patterns that underlie failures, suggesting that more complex dynamics may be at work.

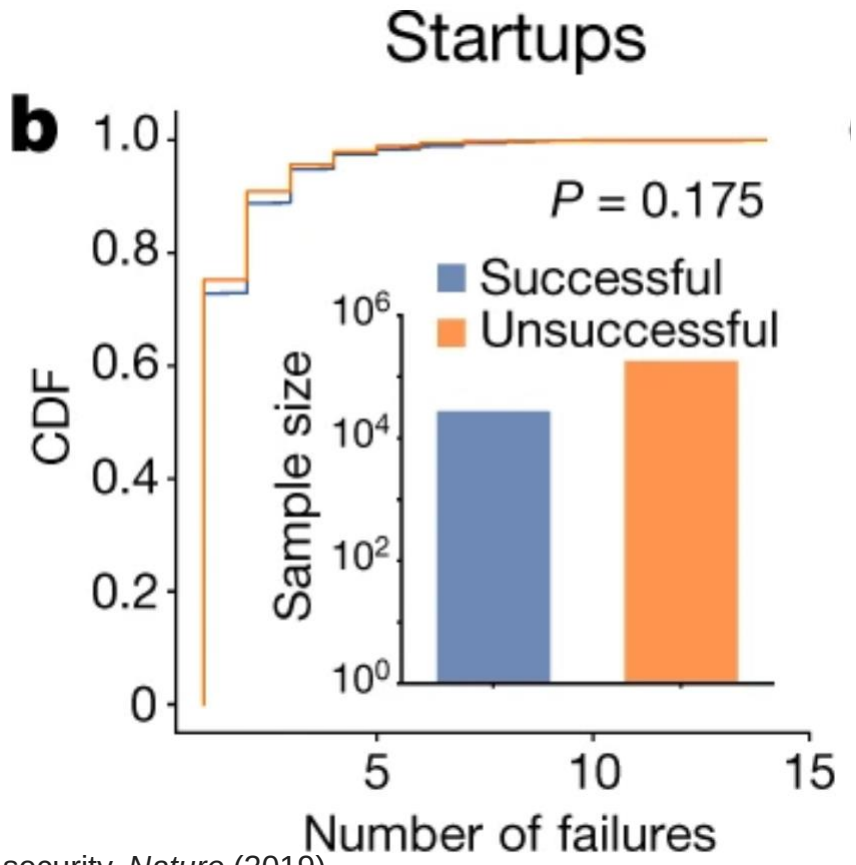


The complementary cumulative distribution function (ccdf) of a random variable is the relative power level against the probability of occurrence

Source: Yin, Y., Wang, Y., Evans, J.A. *et al.* Quantifying the dynamics of failure across science, startups and security. *Nature* (2019)

Successful vs unsuccessful

- The number of failed cases were measured that did not achieve eventual success. It was found that the size of the unsuccessful group is of a **similar order** of magnitude as the successful group.
- The number of consecutive failures before the last attempt for the unsuccessful group follows a statistically **similar distribution** from those that lead to success
- It is suggested that people who ultimately succeeded did not try more or less than their unsuccessful counterpart



Source: Yin, Y., Wang, Y., Evans, J.A. *et al.* Quantifying the dynamics of failure across science, startups and security. *Nature* (2019)

Power-law temporal scaling

- The model predicts that the successful group is characterized by power-law temporal scaling, which is absent for the unsuccessful group. This means that the same principles or processes are at work no matter what the scale of analysis.

- It implies **that the successful and unsuccessful groups may follow fundamentally different failure dynamics** that might be distinguishable at an early stage, with performance improving over time for successful ones.

- A power-law relationship is one where some quantity can be expressed as some power of another. A simple example is

$$Y = \beta x^{\alpha}$$

- *Y* is some response or dependent variable, *x* represents an independent or explanatory variable, β is a normalization constant and α is the scaling exponent

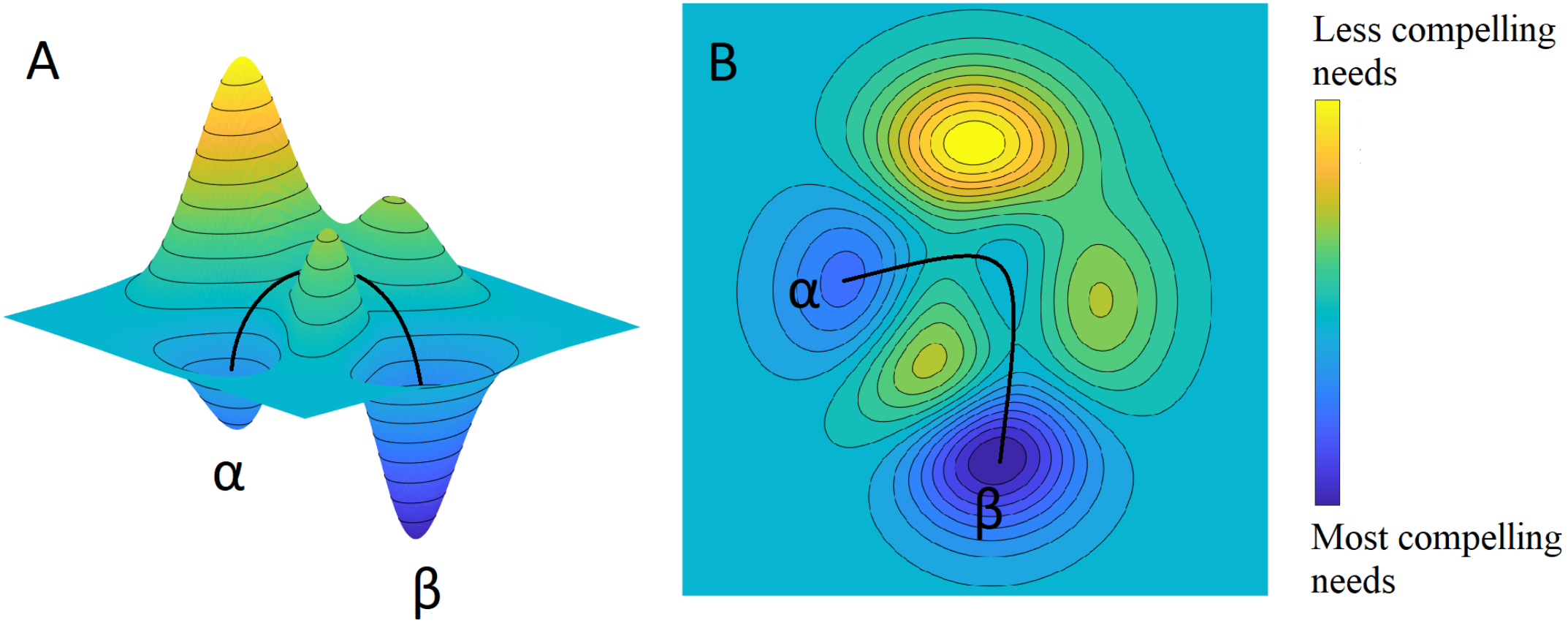
Source: Yin, Y., Wang, Y., Evans, J.A. *et al.* Quantifying the dynamics of failure across science, startups and security. *Nature* (2019); Milne, (1998)

Progression

- Prior start-up experience can positively influences skills for coping with liabilities of newness, effectual reasoning and attitudes towards failures
- **Market pull** is one of the main drivers of the economically successful exploitation of R&D-based development in the innovation process
- A leader should know the **value added** by their organisation and manage this efficiently
- Specific tools can be applied to determine the value that is offered

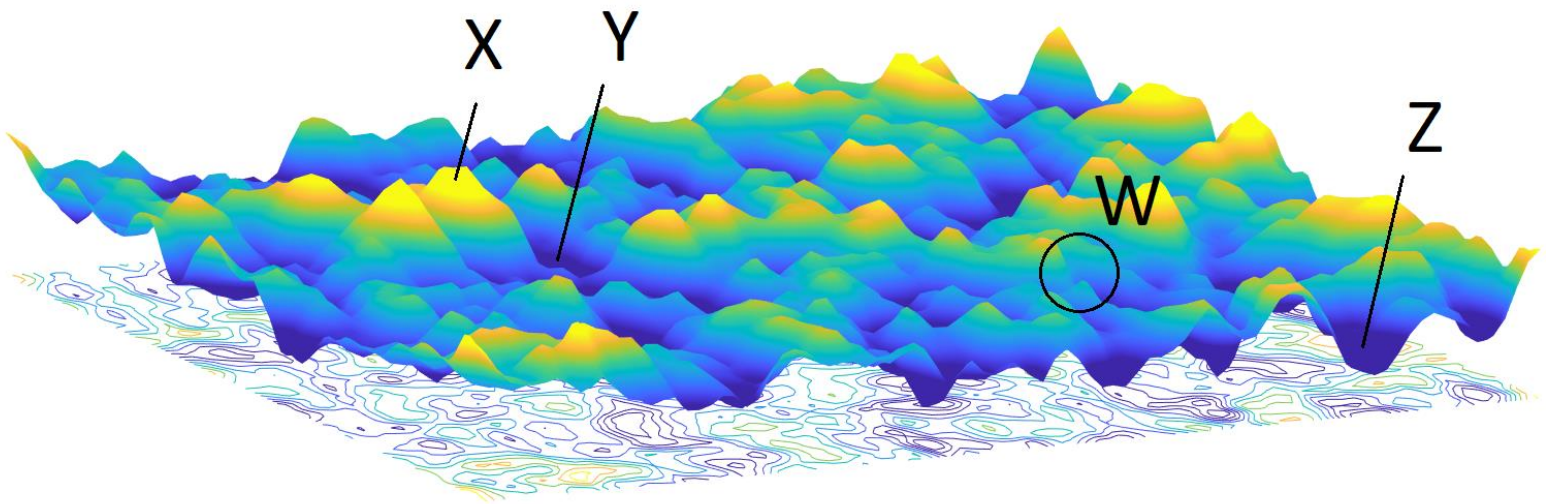
Source: Politis, D. (2008); Tushmann (1988)

Market pull - Finding compelling needs



Tianyou Xu and Jeroen Bergmann, A landscape framework for need-led innovation, under review, 2020

Landscape

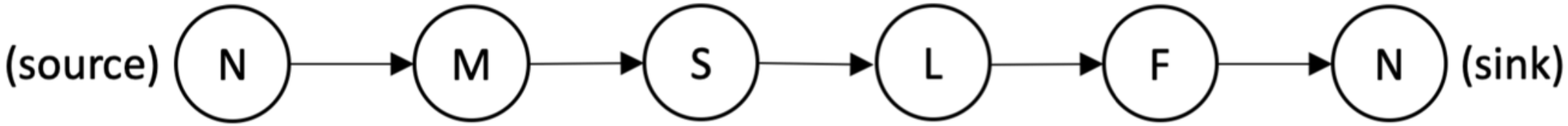


Less compelling needs

Most compelling needs

Tianyou Xu and Jeroen Bergmann, A landscape framework for need-led innovation, under review, 2020

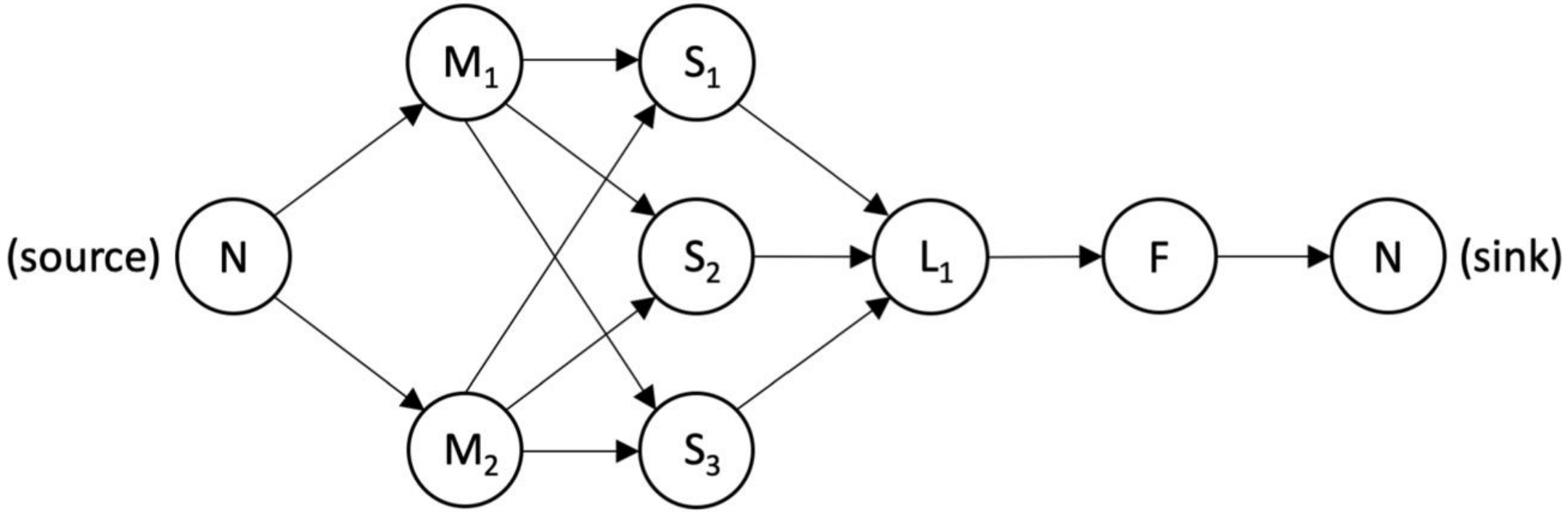
Process



The vertex ***N*** contains a set of needs that flow through stages of market analyses ***M***, stakeholder analyses ***S***, and landscape analyses ***L*** to reach a filtered state ***F*** that yields a set of final needs

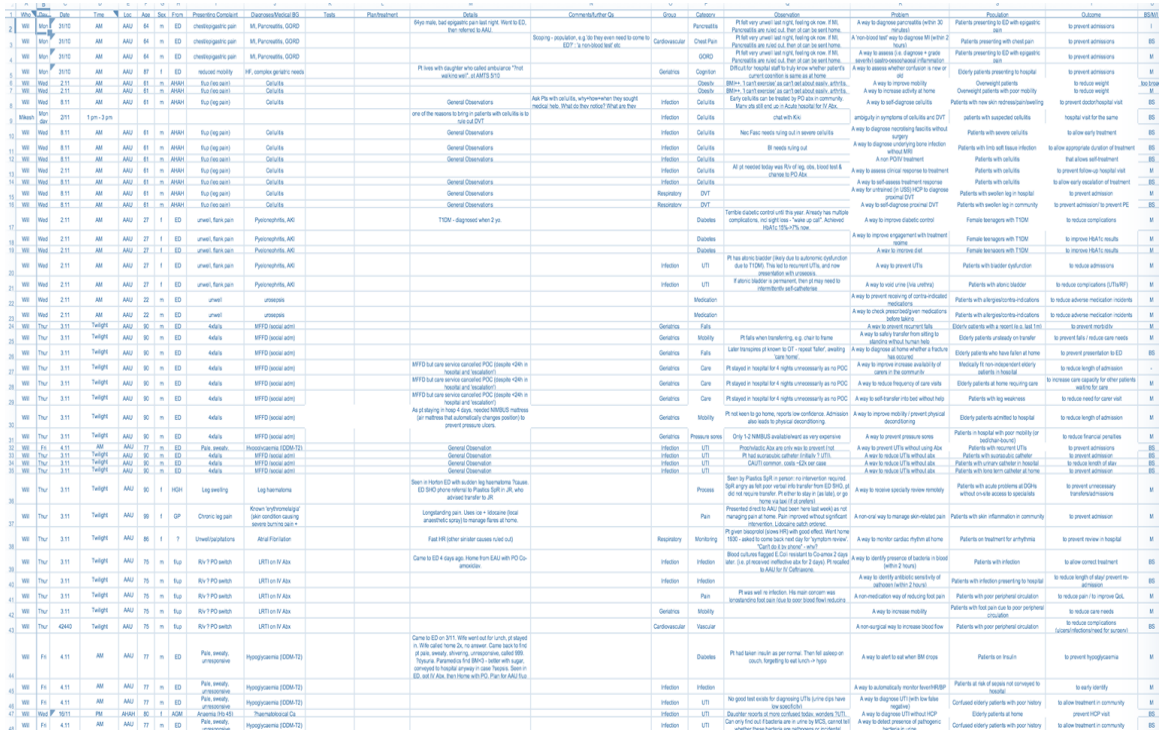
Soliman, E., Mogefors, D. & Bergmann, J.H.M. Problem-driven innovation models for emerging technologies. Health Technol. (2020). https://doi.org/10.1007/s12553-020-00450-5

Process



Soliman, E., Mogefors, D. & Bergmann, J.H.M. Problem-driven innovation models for emerging technologies. Health Technol. (2020). https://doi.org/10.1007/s12553-020-00450-5

Taking the need forward



Who	Day	Date	Time	Loc	Age	Sex	From	Presenting Complaint	Diagnoses/Medical BG	Tests	Plan/Treatment	Details	Comments/further Qs	Group	Category	Observation	Problem	Population	Outcome	BS/AS
WB	Mon	31/10	AM	AAU	64	m	ED	chest/epigastric pain	MI, Pancreatitis, GORD			64yo male, bad epigastric pain last night. Went to ED, then referred to AAU.			Pancreatitis	Pt felt very unwell last night, feeling ok now. If MI, Pancreatitis are ruled out, then ut can be sent home.	A way to diagnose pancreatitis (within 30 minutes).	Patients presenting to ED with epigastric pain	to prevent admissions	-
WB	Mon	31/10	AM	AAU	64	m	ED	chest/epigastric pain	MI, Pancreatitis, GORD				Scoping – population, e.g. 'do they even need to come to ED?', 'a non-blood test' etc.	Cardiovascular	Chest Pain	Pt felt very unwell last night, feeling ok now. If MI, Pancreatitis are ruled out, then ut can be sent home.	A 'non-blood test' way to diagnose MI (within 2 hours)	Patients presenting with chest pain	to prevent admissions	BS
WB	Mon	31/10	AM	AAU	64	m	ED	chest/epigastric pain	MI, Pancreatitis, GORD						GORD	Pt felt very unwell last night, feeling ok now. If MI, Pancreatitis are ruled out, then ut can be sent home.	A way to assess (i.e. diagnose + grade severity) gastro-oesophageal inflammation	Patients presenting to ED with epigastric pain	to prevent admissions	M
WB	Mon	31/10	AM	AAU	87	f	ED	reduced mobility	HF, complex geriatric needs			Pt lives with daughter who called ambulance "I'not walk'ins well", st AMTS 5/10		Geriatrics	Cognition	Difficult for hospital staff to truly know whether patients current condition is same as at home	A way to assess whether confusion is new or old	Elderly patients presenting to hospital	to prevent admissions	M
WB	Wed	2.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis						Obesity	BMI>+, 'I can't exercise' as can't set about easily, arthritis	A way to improve mobility	Overweight patients	to reduce weight	No bmw
WB	Wed	2.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis						Obesity	BMI>+, 'I can't exercise' as can't set about easily, arthritis	A way to increase activity at home	Overweight patients with poor mobility	to reduce weight	M
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations	Ask Pts with cellulitis, why+how+when they sought medical help. What do they notice? What are they	Infection	Cellulitis	Early cellulitis can be treated by PO abx in community. Many pts still end up in Acute hospital for IV Abx.	A way to self-diagnose cellulitis	Patients with new skin redness/pain/swelling	to prevent doctor/hospital visit	BS
Mikeal	Mon day	2/11	1 pm - 3 pm									one of the reasons to bring in patients with cellulitis is to rule out DVT		Infection	Cellulitis	chat with KVo	ambiguity in symptoms of cellulitis and DVT	patients with suspected cellulitis	hospital visit for the same	BS
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Infection	Cellulitis	Nec Fasc needs ruling out in severe cellulitis	A way to diagnose necrotising fasciitis without surgery	Patients with severe cellulitis	to allow early treatment	BS
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Infection	Cellulitis	BI needs ruling out	A way to diagnose underlying bone infection without MRI	Patients with Imb soft tissue infection	to allow appropriate duration of treatment	BS
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Infection	Cellulitis		A non POIV treatment	Patients with cellulitis	that allows self-treatment	BS
WB	Wed	2.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis					Infection	Cellulitis	All pt needed today was RVs of leg, sbs, blood test & chanse to PO Abx	A way to assess clinical response to treatment	Patients with cellulitis	to prevent follow-up hospital visit	M
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Infection	Cellulitis		A way to self-assess treatment response	Patients with cellulitis	to allow early escalation of treatment	BS
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Respiratory	DVT		A way for untrained (in USS) HCP to diagnose proximal DVT	Patients with swollen leg in hospital	to prevent admission	M
WB	Wed	8.11	AM	AAU	61	m	AHAH	flu/ (leg pain)	Cellulitis			General Observations		Respiratory	DVT		A way to self-diagnose proximal DVT	Patients with swollen leg in community	to prevent admission/ to prevent PE	BS
WB	Wed	2.11	AM	AAU	27	f	ED	unwell, flank pain	Pyelonephritis, AKI			T1DM - diagnosed when 2 yo.		Infection	Diabetes	Terrible diabetic control until this year. Already has multiple complications, not right now - "wake up call". Achieved HbA1c 15%->7% now.	A way to improve diabetic control	Female teenagers with T1DM	to reduce complications	M
WB	Wed	2.11	AM	AAU	27	f	ED	unwell, flank pain	Pyelonephritis, AKI						Diabetes		A way to improve engagement with treatment regime	Female teenagers with T1DM	to improve HbA1c results	M
WB	Wed	2.11	AM	AAU	27	f	ED	unwell, flank pain	Pyelonephritis, AKI						Diabetes		A way to interview dad	Female teenagers with T1DM	to improve HbA1c results	M
WB	Wed	2.11	AM	AAU	27	f	ED	unwell, flank pain	Pyelonephritis, AKI					Infection	UTI	Pt has atonic bladder (likely due to autonomic dysfunction due to T1DM). This led to recurrent UTIs, and now presentation with urosepsis.	A way to prevent UTIs	Patients with bladder dysfunction	to reduce admissions	M
WB	Wed	2.11	AM	AAU	27	f	ED	unwell, flank pain	Pyelonephritis, AKI			If atonic bladder is permanent, then pt may need to intermittently self-catheterise.		Infection	UTI		A way to void urine (via urethra)	Patients with atonic bladder	to reduce complications (UTIs/RF)	M
WB	Wed	2.11	AM	AAU	22	m	ED	unwell	urosepsis						Medication		A way to prevent receiving of contra-indicated medications	Patients with allergies/contra-indications	to reduce adverse medication incidents	M
WB	Wed	2.11	AM	AAU	22	m	ED	unwell	urosepsis						Medication		A way to check prescribed/given medications before taking	Patients with allergies/contra-indications	to reduce adverse medication incidents	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)					Geriatrics	Falls		A way to prevent recurrent falls	Elderly patients with a recent (e.a. last 1m)	to prevent morbidity	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)					Geriatrics	Mobility	Pt falls when transferring, e.g. chair to frame	A way to safely transfer from sitting to standing without human help	Elderly patients unsteady on transfer	to prevent falls / reduce care needs	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)					Geriatrics	Falls	Later transpires pt known to OT – repeat 'faller', awaiting 'care home'.	A way to diagnose at home whether a fracture has occurred	Elderly patients who have fallen at home	to prevent presentation to ED	BS
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			MFFD but care service cancelled POC (despite <24h in hospital and 'escalation')		Geriatrics	Care	Pt stayed in hospital for 4 nights unnecessarily as no POC	A way to improve increase availability of carers in the community/ie.	Medically fit non-independent elderly patients in hospital	to reduce length of admission	-
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			MFFD but care service cancelled POC (despite <24h in hospital and 'escalation')		Geriatrics	Care	Pt stayed in hospital for 4 nights unnecessarily as no POC	A way to reduce frequency of care visits	Elderly patients at home requiring care	to increase care capacity for other patients waiting for care.	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			MFFD but care service cancelled POC (despite <24h in hospital and 'escalation')		Geriatrics	Care	Pt stayed in hospital for 4 nights unnecessarily as no POC	A way to self-transfer into bed without help	Patients with leg weakness	to reduce need for carer visit	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			As pt staying in hosp 4 days, needed NIMBUS mattress (air mattress that automatically changes position) to prevent pressure ulcers.		Geriatrics	Mobility	Pt not keen to go home, reports low confidence. Admission also leads to physical deconditioning.	A way to improve mobility / prevent physical deconditioning	Elderly patients admitted to hospital	to reduce length of admission	M
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)					Geriatrics	Pressure sores	Only 1-2 NIMBUS available/ward/ as very expensive	A way to prevent pressure sores	Patients in hospital with poor mobility (or bed/chair-bound)	to reduce financial penalties	M
WB	Fri	4.11	AM	AAU	77	m	ED	Pale, sweaty, unresponsive	Hypoglycaemia (CDM-T2)			General Observation.		Infection	UTI	Prophylactic Abx are only way to prevent (not	A way to prevent UTIs without using Abx	Patients with recurrent UTIs	to prevent admissions	BS
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			General Observation.		Infection	UTI	Pt had eucrassilic catheter (initially 7 UTI).	A way to reduce UTIs without abx	Patients with eucrassilic catheter	to prevent admission	BS
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			General Observation.		Infection	UTI	CAUTI common. coals –E2k per case.	A way to reduce UTIs without abx	Patients with urinary catheter in hospital	to reduce lenath of stay	BS
WB	Thu	3.11	Twilight	AAU	90	m	ED	4ds/a	MFFD (social adm)			General Observation.		Infection	UTI		A way to reduce UTIs without abx	Patients with long term catheter at home	to prevent admission	BS
WB	Thu	3.11	Twilight	AAU	90	f	HGH	Leg swelling	Leg haematoma			Seen in Horton ED with sudden leg haematoma 7cases. ED SHO phone referral to Plastics. Spiff in JR, who advised transfer to JR.		Process		Seen by Plastics SpR in person: no intervention required. SpR angry as felt poor verbal info transfer from ED SHO, pt did not require transfer. Pt either to stay in (as late), or go home via bed (if at prefer).	A way to receive specialty review remotely	Patients with acute problems at DGHs without on-site access to specialists	to prevent unnecessary transfers/admissions	M
WB	Thu	3.11	Twilight	AAU	99	f	GP	Chronic leg pain	Known 'erythromelalgia' (skin condition causing severe burning pain) +			Longstanding pain. Uses ice + lidocaine (local anaesthetic spray) to manage flares at home.		Pain		Presented direct to AAU (had been here last week) as not managing pain at home. Pain improved without significant intervention. Lidocaine patch ordered.	A non-oral way to manage skin-related pain	Patients with skin inflammation in community	to prevent admission	M
WB	Thu	3.11	Twilight	AAU	86	f	?	Unwell/palpitations	Atrial Fibrillation			Fast HR (other sinister causes ruled out)		Respiratory	Monitoring	Pt given diazepam (cures HR) with good effect. Went home 1930 - asked to come back next day for 'symptom review'. 'Can't do it by phone' - why?	A way to monitor cardiac rhythm at home	Patients on treatment for arrhythmia	to prevent review in hospital	M
WB	Thu	3.11	Twilight	AAU	75	m	flu/p	Rx 7 PO switch	URTI on IV Abx			Came to ED 4 days ago. Home from EAU with PO Co-amoxiclav.		Infection	Infection	Blood cultures flagged E.Coli resistant to Co-amox 2 days later. (i.e. pt received ineffective abx for 2 days). Pt recalled to AAU for IV Ceftriaxone.	A way to identify presence of bacteria in blood (within 2 hours)	Patients with infection	to allow correct treatment	BS
WB	Thu	3.11	Twilight	AAU	75	m	flu/p	Rx 7 PO switch	URTI on IV Abx					Infection	Infection		A way to identify antibiotic sensitivity of pathogen (within 2 hours)	Patients with infection presenting to hospital	to reduce length of stay/ prevent re-admission	BS
WB	Thu	3.11	Twilight	AAU	75	m	flu/p	Rx 7 PO switch	URTI on IV Abx				Pt was wel re infection. His main concern was lumbar/sinitis foot pain (due to poor blood flow) reducing	Pain		Pt was wel re infection. His main concern was lumbar/sinitis foot pain (due to poor blood flow) reducing	A non-medication way of reducing foot pain	Patients with poor peripheral circulation	to reduce pain / to improve QoL	M
WB	Thu	3.11	Twilight	AAU	75	m	flu/p	Rx 7 PO switch	URTI on IV Abx					Geriatrics	Mobility		A way to increase mobility	Patients with foot pain due to poor peripheral circulation	to reduce care needs	M
WB	Thu	42443	Twilight	AAU	75	m	flu/p	Rx 7 PO switch	URTI on IV Abx					Cardiovascular	Vascular		A non-surgical way to increase blood flow	Patients with poor peripheral circulation	to reduce complications (ulcers/infections/need for surgery)	BS
WB	Fri	4.11	AM	AAU	77	m	ED	Pale, sweaty, unresponsive	Hypoglycaemia (CDM-T2)			Came to ED on 3/11. Wife went out for lunch, pt stayed in. Wife called home 2x, no answer. Came back to find pt pale, sweaty, shivering, unresponsive, called 999. 7oysuria. Paramedics find BM=3 - better with sugar, conveyed to hospital anyway in case Twoisia. Seen in ED, got IV Abx, then Home with PO. Plan for AAU f/up.		Diabetes		Pt had taken insulin as per normal. Then fell asleep on couch, forgetting to eat lunch -> hypo	A way to alert to eat when BM cross	Patients on Insulin	to prevent hypoglycaemia	M
WB	Fri	4.11	AM	AAU	77	m	ED	Pale, sweaty, unresponsive	Hypoglycaemia (CDM-T2)					Infection	Infection		A way to automatically monitor fever/HR/BP	Patients at risk of sepsis not conveyed to hospital	to early identify	M
WB	Fri	4.11	AM	AAU	77	m	ED	Pale, sweaty, unresponsive	Hypoglycaemia (CDM-T2)					Infection	UTI	No good test exists for diagnosing UTIs (urine dips have low sens/spec)	A way to diagnose UTI (with low false negative)	Confused elderly patients with poor history	to allow treatment in community	M
WB	Wed	10/11	PM	AHAH	80	f	AGM	Anaemia (Hb 63)	Thalassaemia Ca				Daughter reports (4 more confused today, wonders TUTI.	Infection	UTI	Can only find out if bacteria are in urine by MCS, cannot tell	A way to diagnose UTI without HCP	Elderly patients at home	prevent HCP visit	BS
WB	Fri	4.11	AM	AAU	77	m	ED	Pale, sweaty, unresponsive	Hypoglycaemia (CDM-T2)					Infection	UTI		A way to detect presence of pathogenic bacteria in urine	Confused elderly patients with poor history	to allow treatment in community	BS

Business model canvas

- It is a tool to develop new (or assess existing) business models in a structured manner.
- It aims to make insightful any trade-offs you might have to make.
- It can help with the strategic management of the business and highlight risks and opportunities.
- Teams that used the elements of customer segment, value proposition, key activities / partnerships performed significantly better in an explorative study.

Ladd, T. (2018), "Does the business model canvas drive venture success?", Journal of Research in Marketing and Entrepreneurship, Vol. 20 No. 1, pp. 57-69. https://doi.org/10.1108/JRME-11-2016-0046

Business model canvas

Business model canvas

Key partners

What external partnerships should you invest in?

Mentors?
Lawyers?
Distributors?
Suppliers?

Key activities

What will your business spend the most time doing?

Product development?
Sales? Other?

Key resources

What will it cost for:

Manufacturing?
Intellectual property?
Human resources?

Value proposition

What value do we deliver to the customer?

Which one of our customers' problems are we helping to solve?

What bundles of products and services are we offering to each segment?

Which customer needs are we satisfying?

What is the minimum viable product?

Costumer relationship

What types of interactions will your customers expect to have with you?

Channels

How will customers find out about you?

How will you get products to them?

Costumer segments

Who are your paying customers?

Do you have any non-paying customers?

How large is this group?

Do you have multiple customer segments?

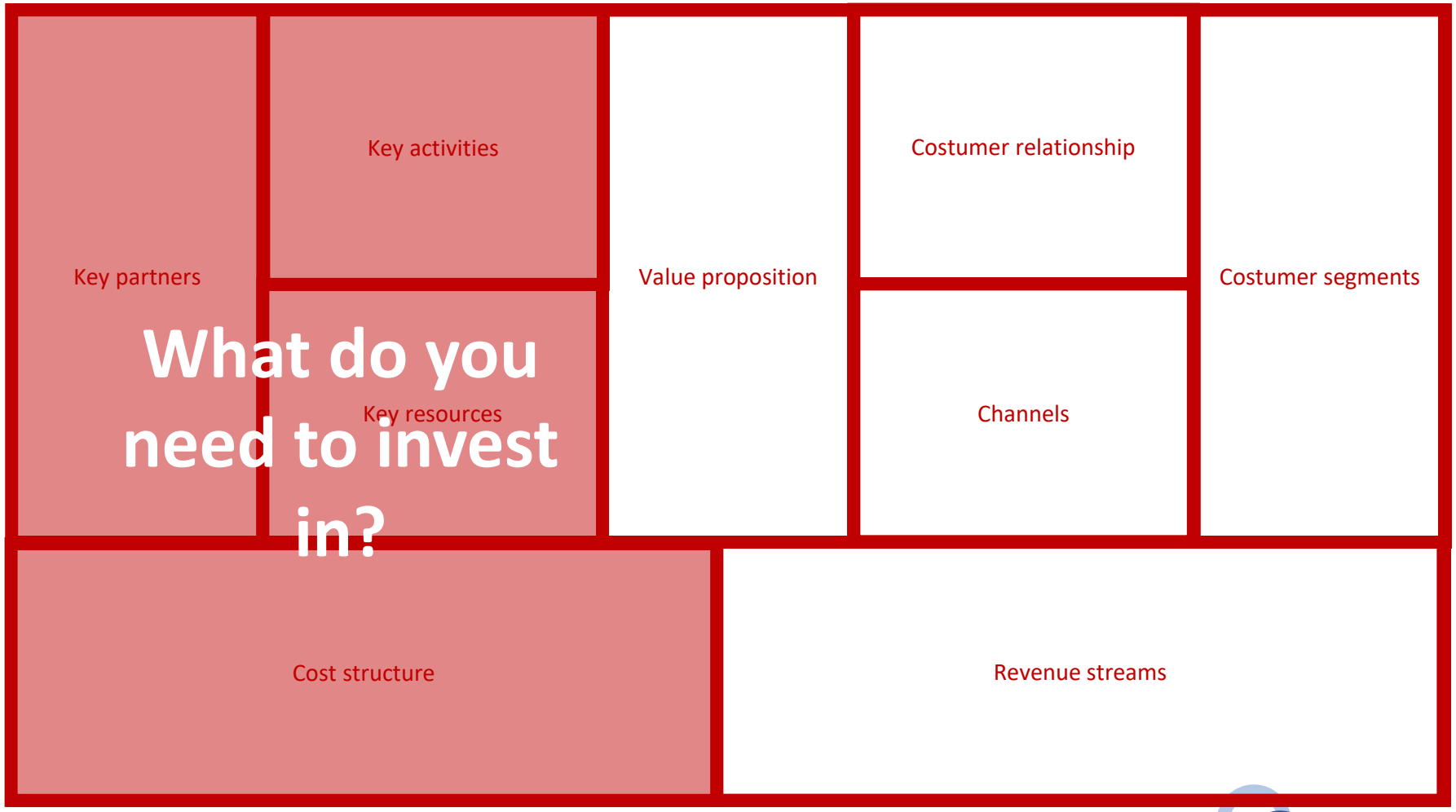
Cost structure

How much time and money will be required to do this?
What are the most important costs inherent to our business model?
Which key resources are most expensive?
Which key activities are most expensive?

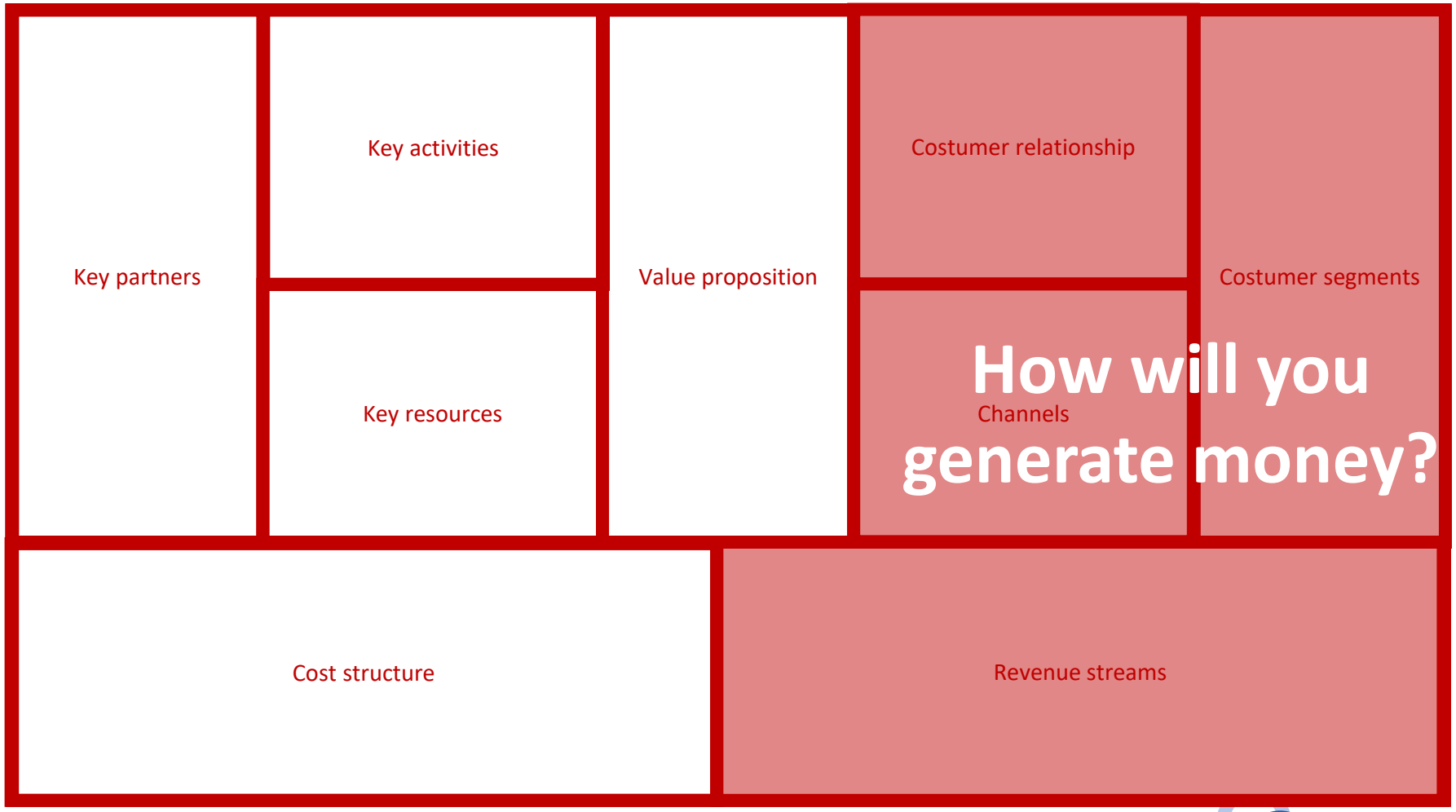
Revenue streams

How might you make money from this?
What value, other than money, are you hoping to create?
For what value are our customers really willing to pay?
For what do they currently pay?
What is the revenue model?
What are the pricing tactics?

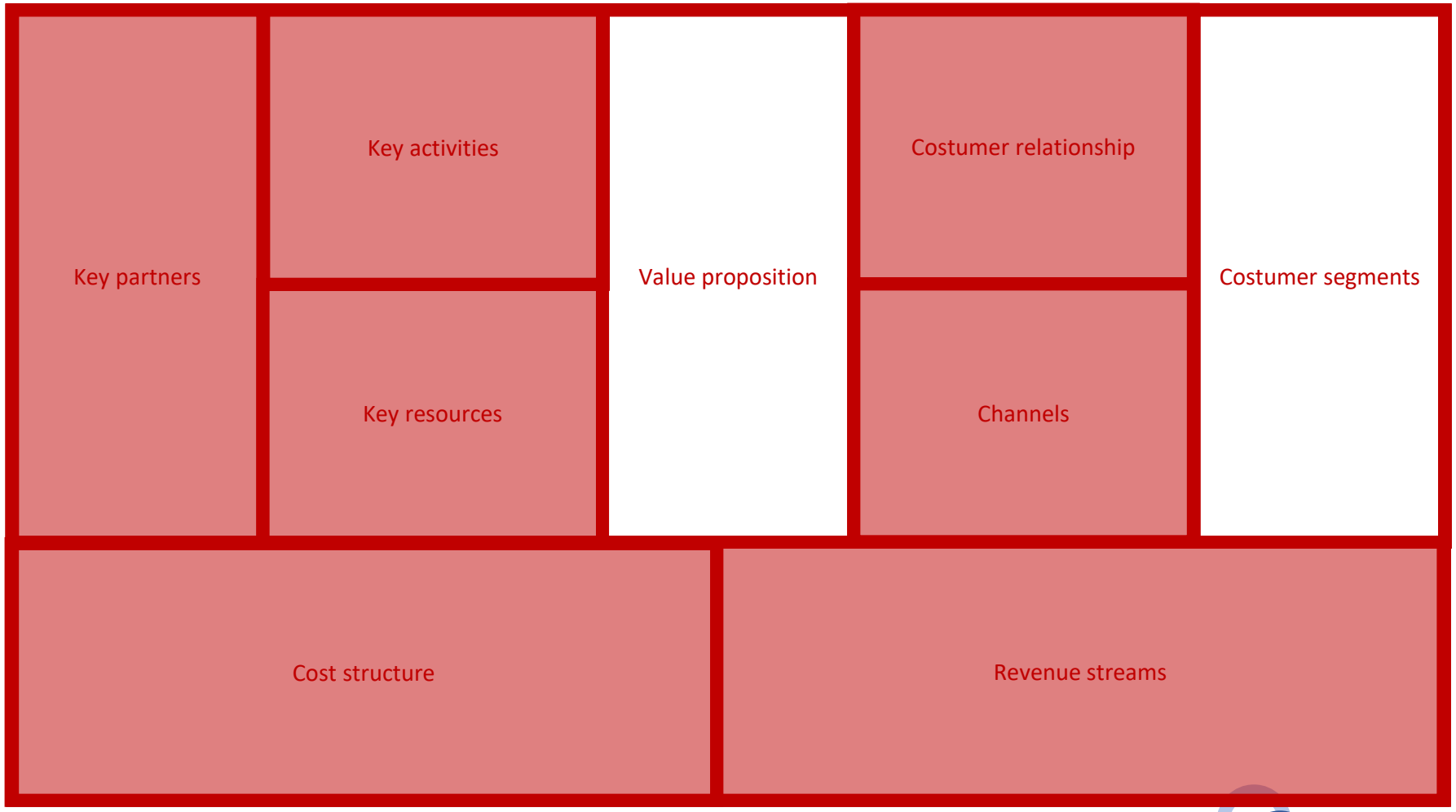
Business model canvas



Business model canvas



Business model canvas



Questions we want to ask

- Process or product?
- Software or services?
- Provider or patient?
- Open or proprietary?
- Content or data?
- Freemium or premium?
- Subscription or license?
- Unregulated or regulated?

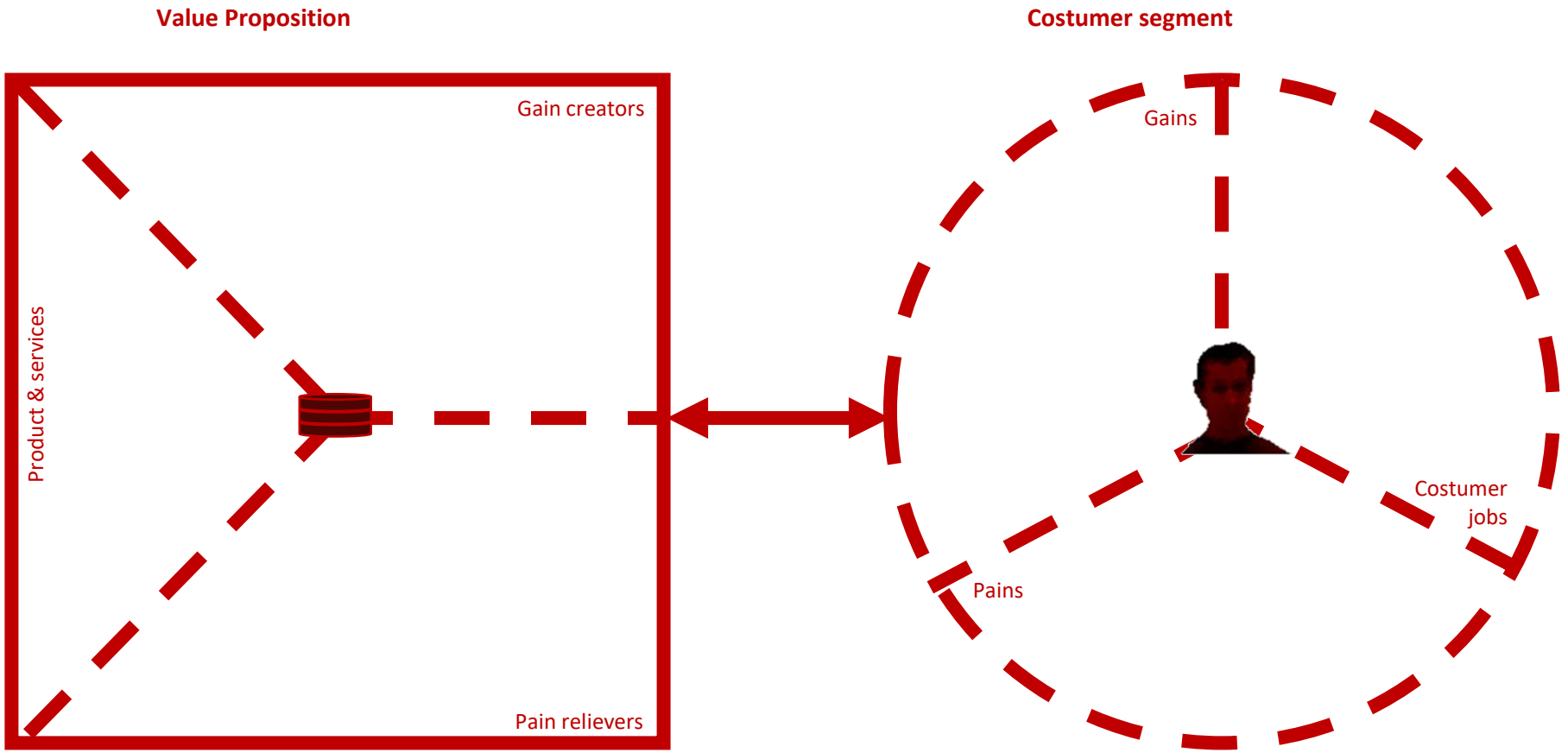
It all starts with the value of solving **a certain need** for **a certain costumer** and thus **adding value**

Introduction Value Canvas

- Tool to help you build with greater detail the two sections of the business model

- Determine how well your offering fits the costumer needs or wants

Overview



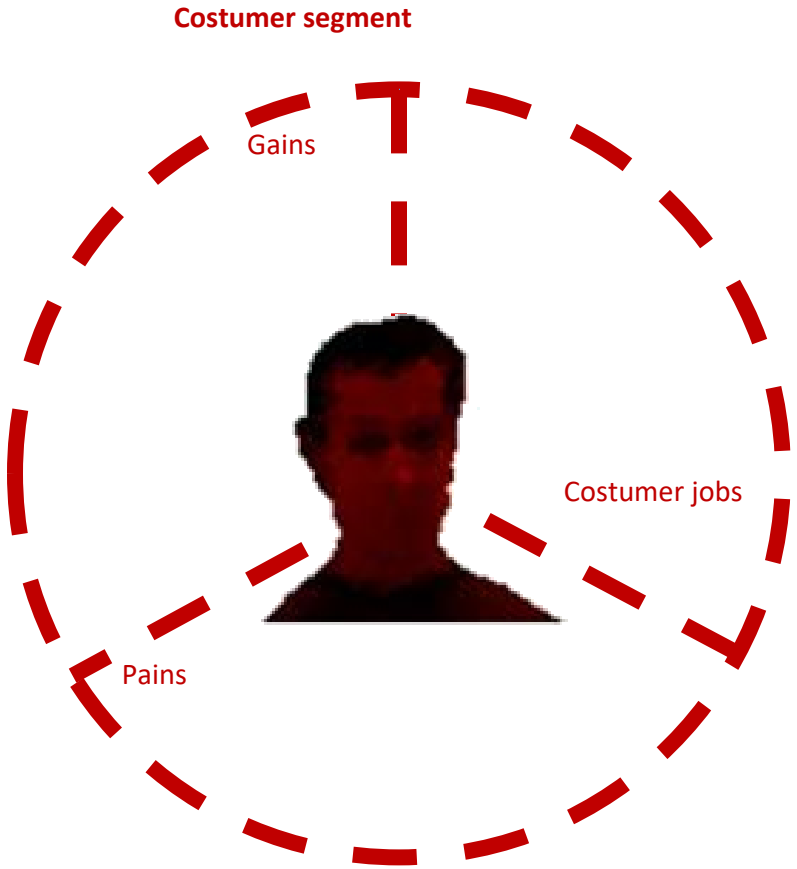
Costumer segment

- Jobs the costumers want to get done in work and life.

- Negative aspects the costumers would like to avoid.

- Positive aspects or benefits the costumers would like to have.

You should be able to observe/measure these aspects.



Costumer segment

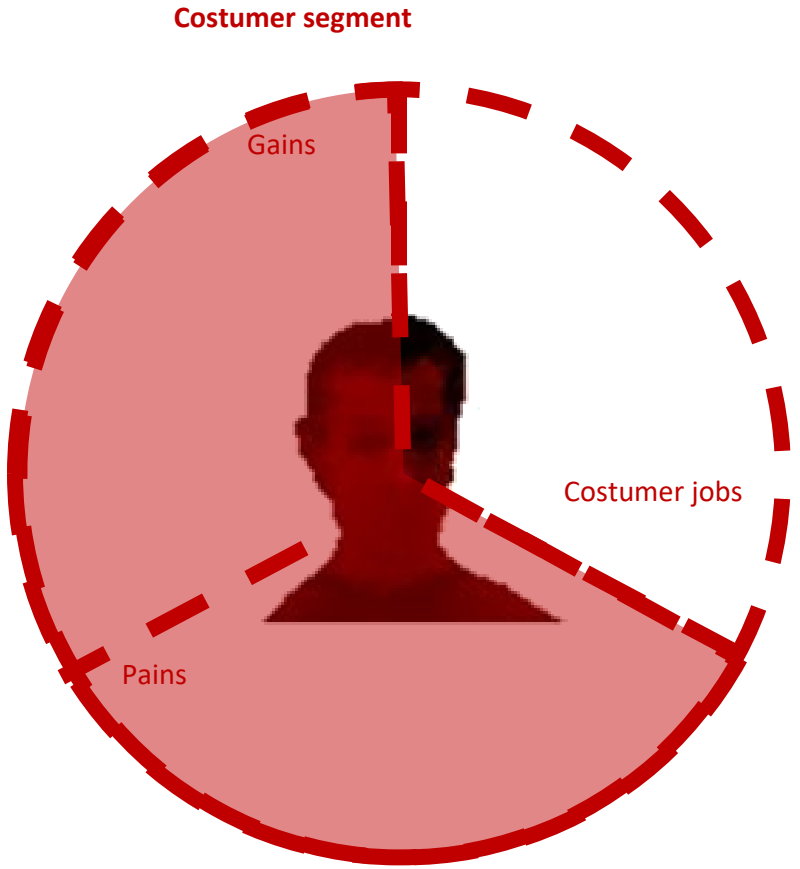
- Let’s start

Costumer jobs

- Tasks that the costumer wants to complete.
- Problems that they are trying to solve.
- **Needs** that they are trying to address.

Fill in the costumer's needs and rank them.

[Functional, emotional, perceived needs]

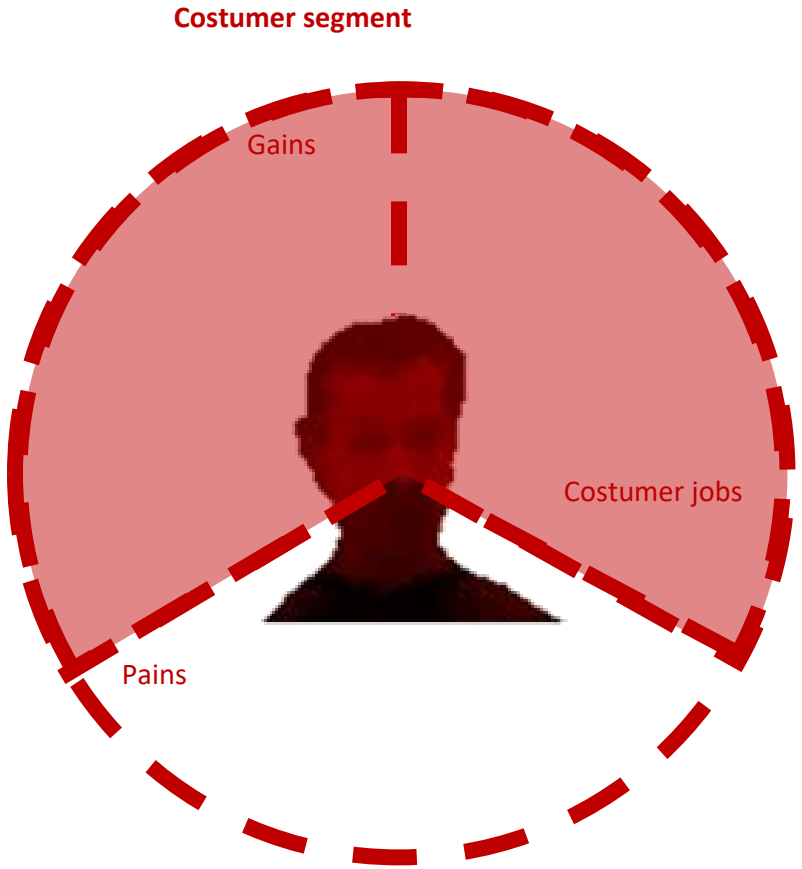


Pains

- Pains before the job starts.
- Pains during the job.
- Pains after the job is finished.

Fill in the costumer's pains and rank them.

[cost, emotional, time effects]

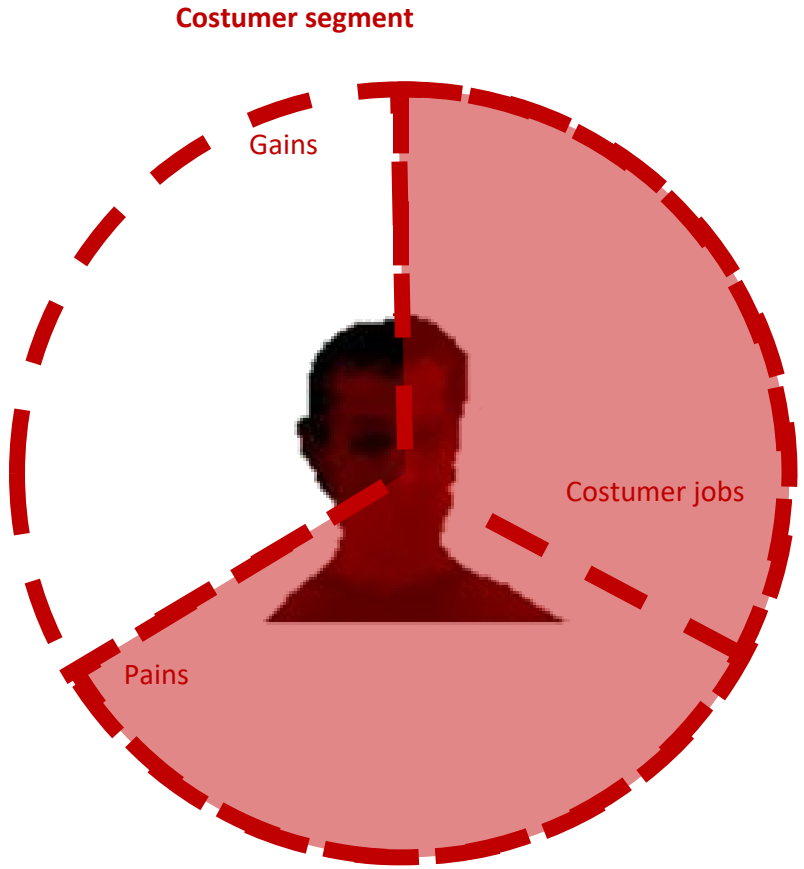


Gains

- Benefits your costumer expect.
- Benefits your costumer require.
- Benefits your costumer desire.

Fill in the costumer's benefits and rank them.

[cost, emotional, time]



Costumer segment

- Completed the costumer segment.

- You can also answer:
- Who are your paying customers?
- How large is this group?
- Do you have multiple customer segments?
- …

Value proposition

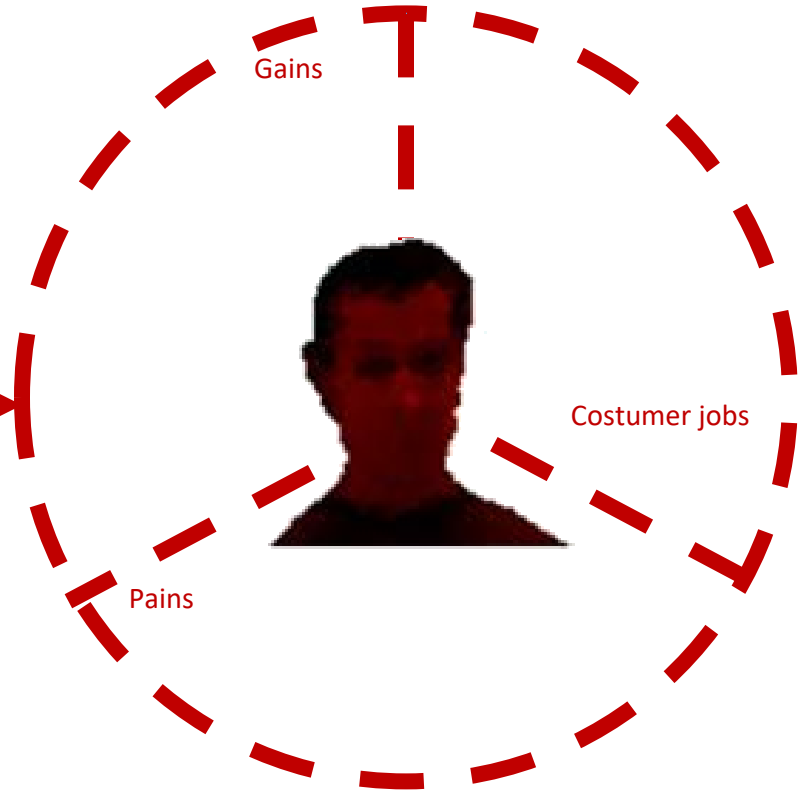
Value proposition

Value Proposition

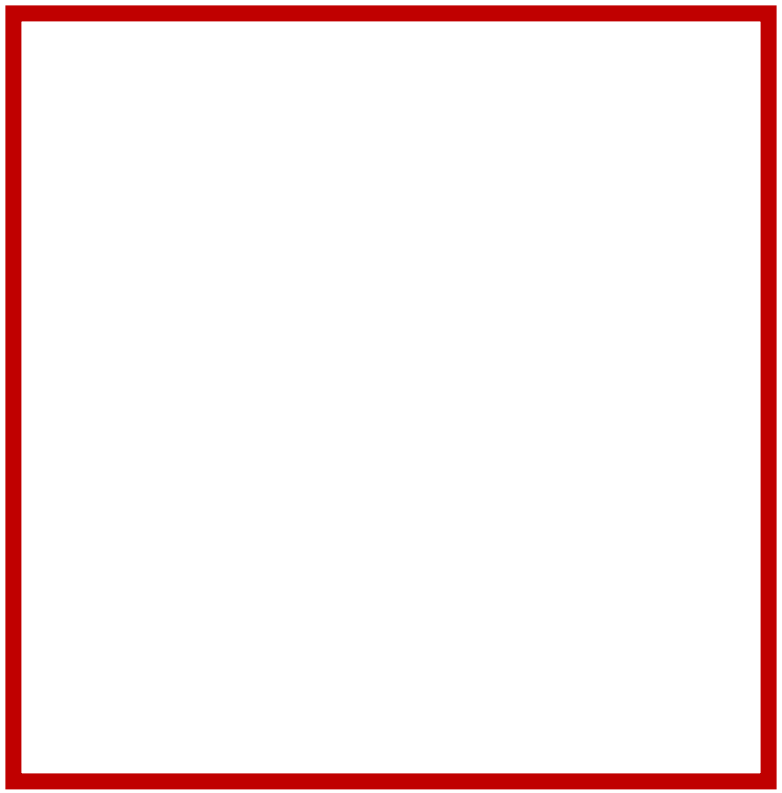
Designed to address:

- Highest ranking jobs
- Highest ranking pains
- Highest ranking gains

Costumer segment



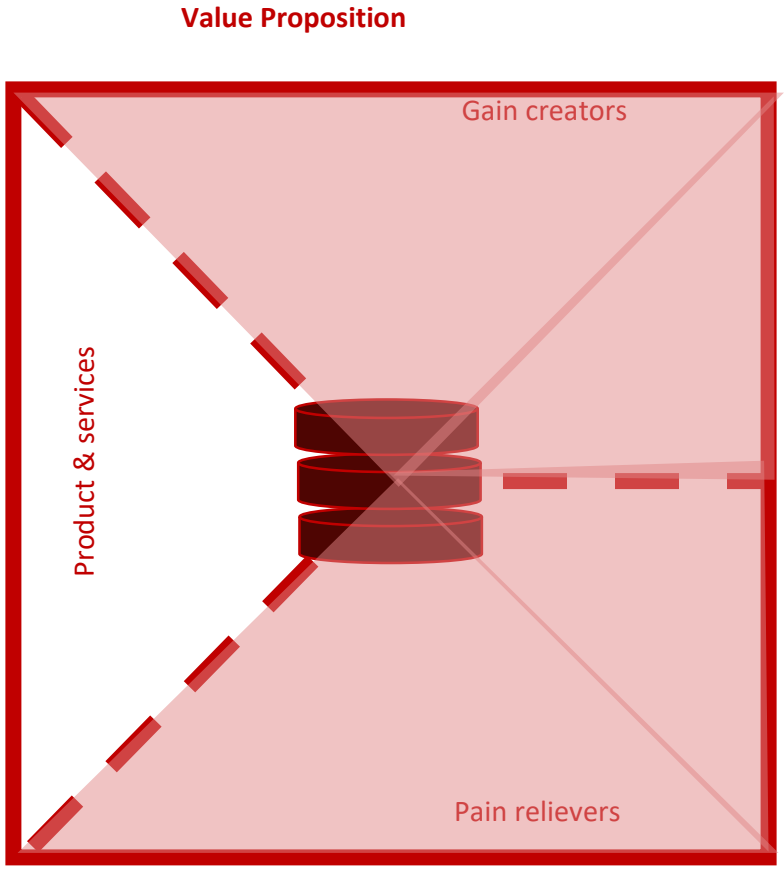
Value proposition



Designed around:

- Product and services needed for your value proposition.
- How you elevate costumer’s pains.
- How you create positive gains.

Product and services

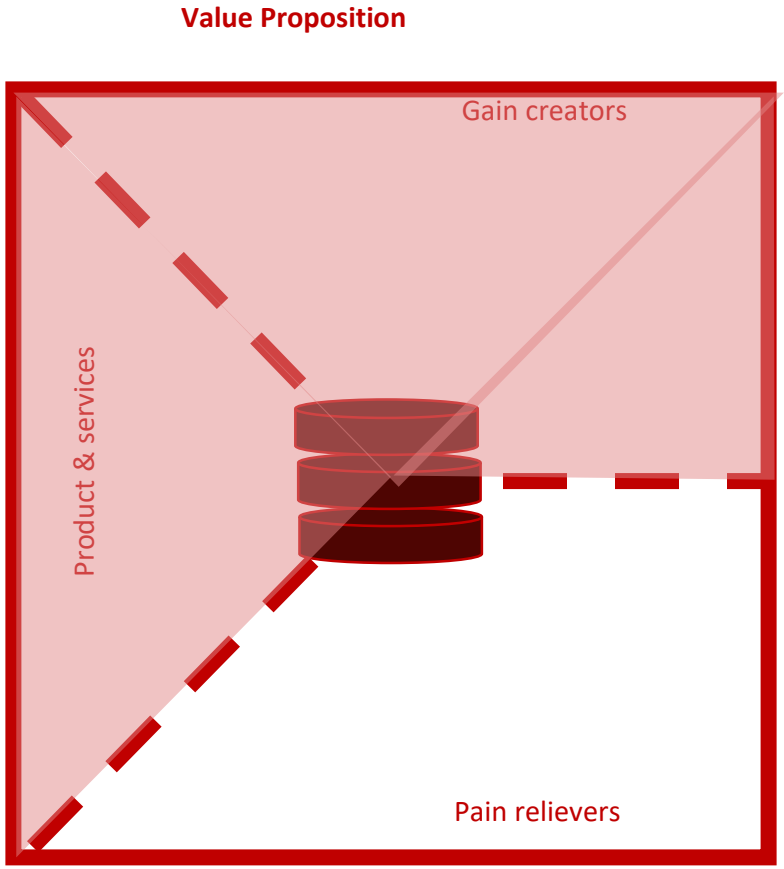


Product & services offered

- To get the job done
- To address the pains
- To optimise the gains

Define your product and services (solution)

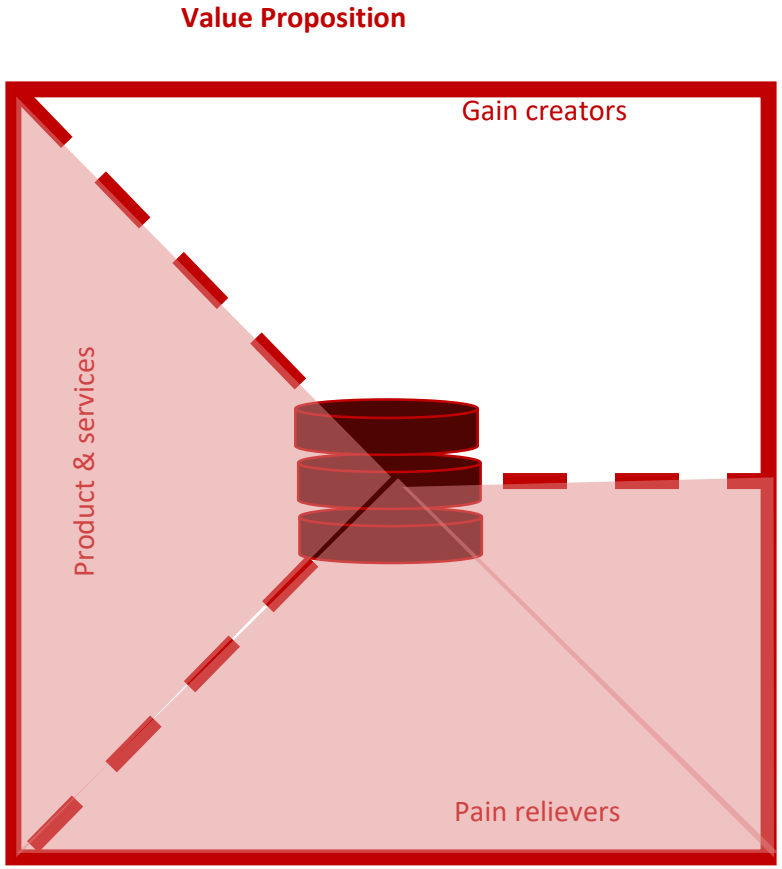
Pain relievers



- Clearly state how your product will eliminate or reduce pains.
- Should be able to counter pains in costumer segment.

Define your pain relievers

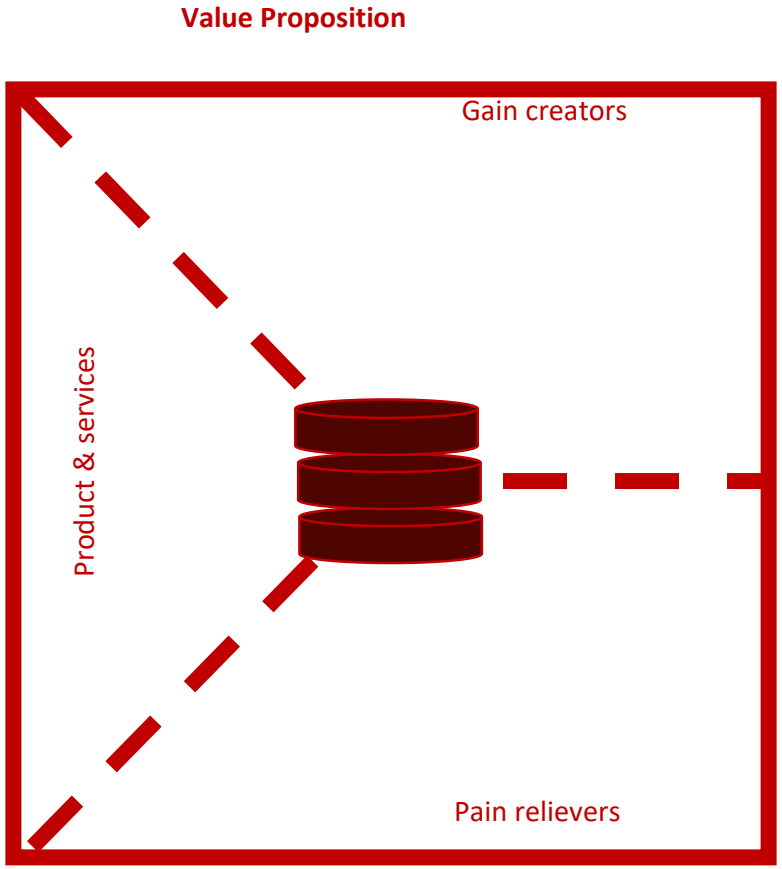
Gain creators



- Clearly state how your product will create gains.
- Should be able to link to gains in costumer segment.

Define your gain creators

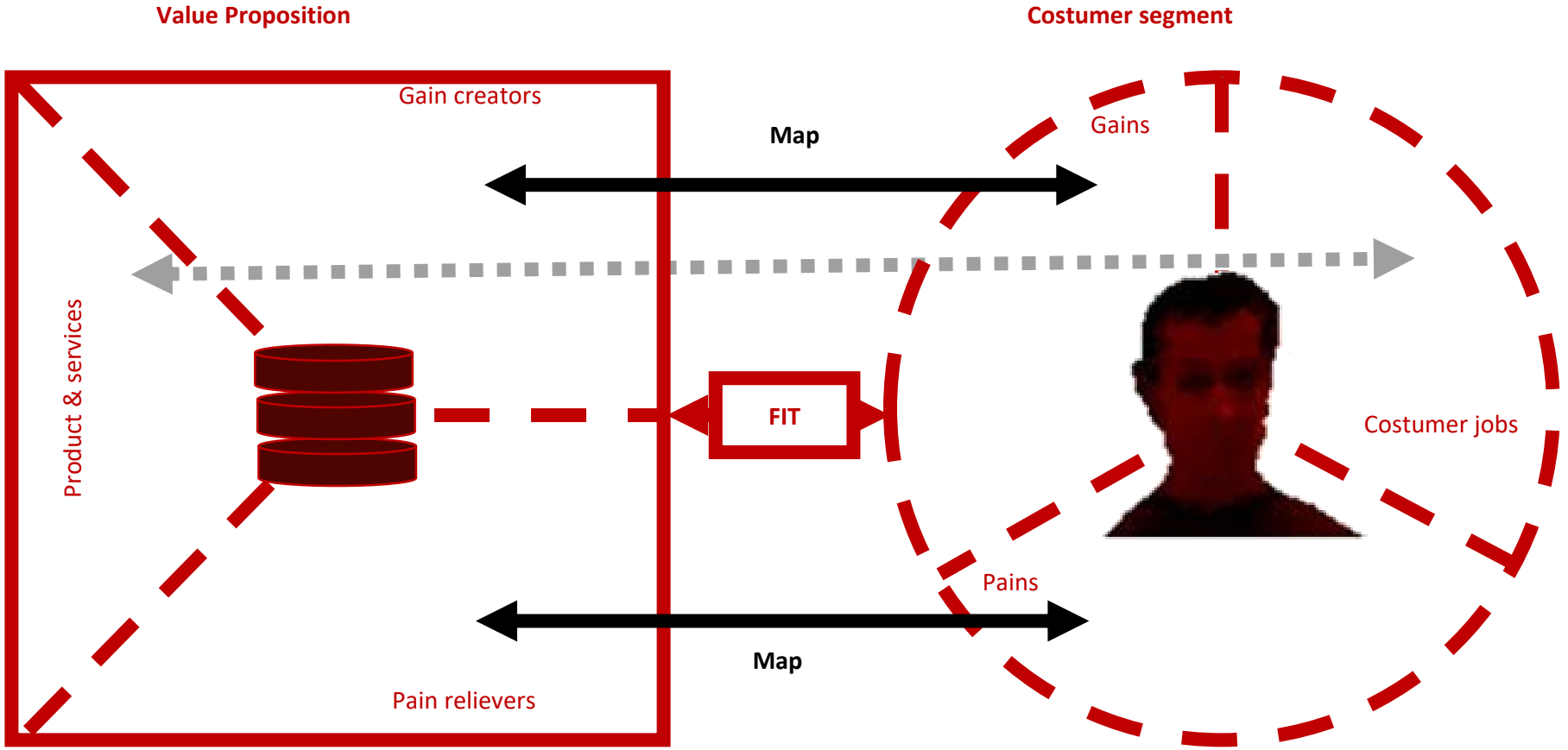
Value proposition



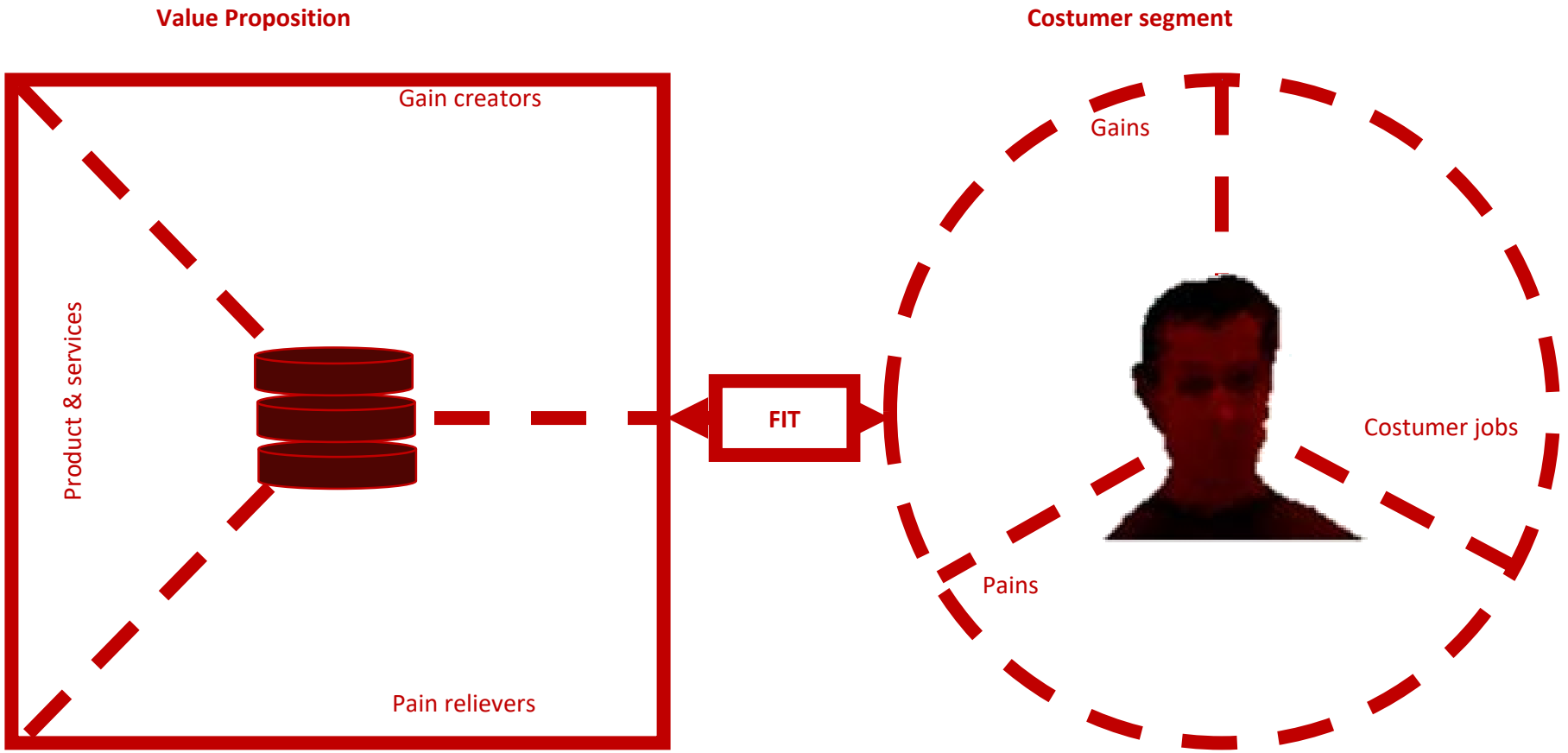
- Completed the value proposition.

- You should also be able to answer:
- What bundles of products and services are you offering to **each** segment?
- What is the minimum viable product (**MVP**)?
- …

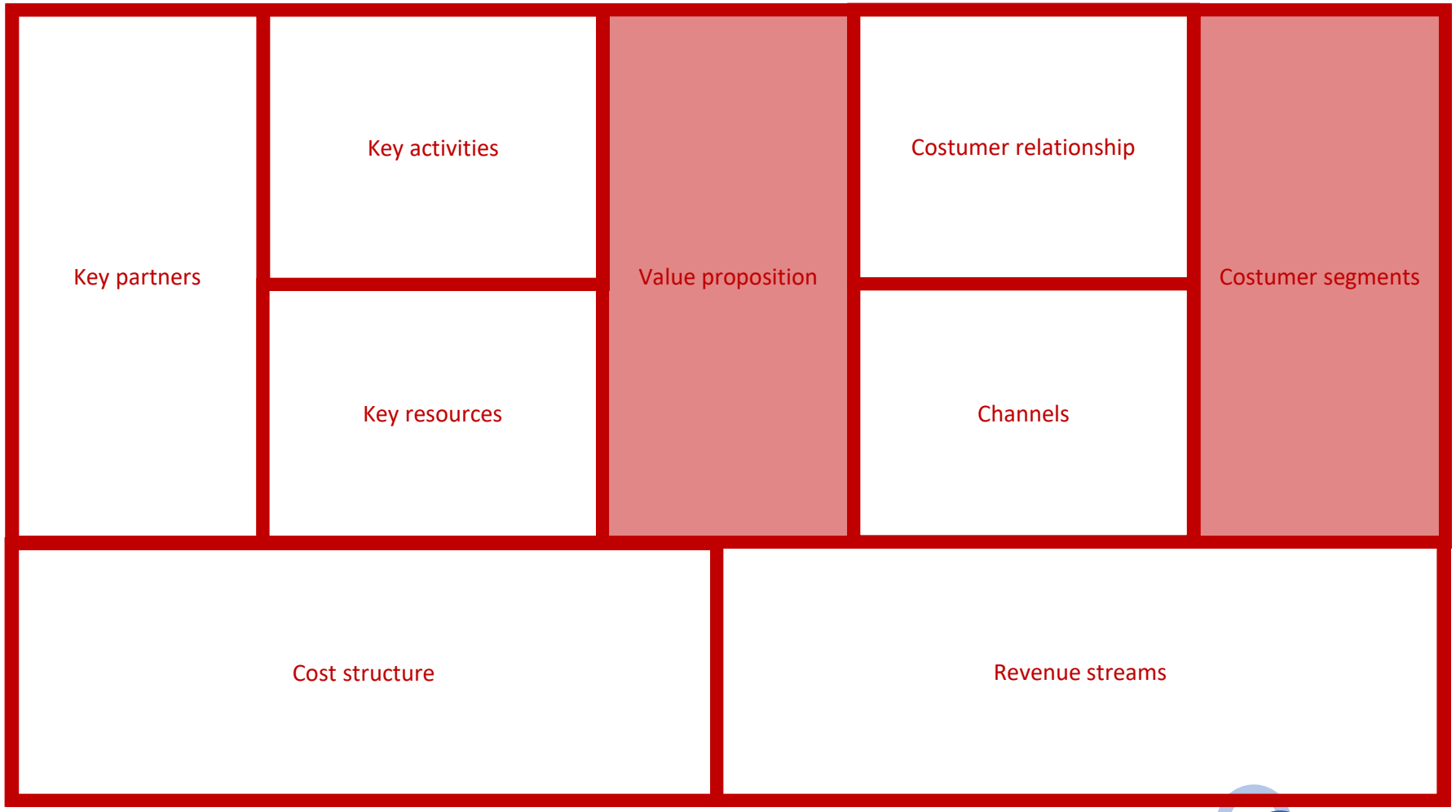
Value proposition mapping



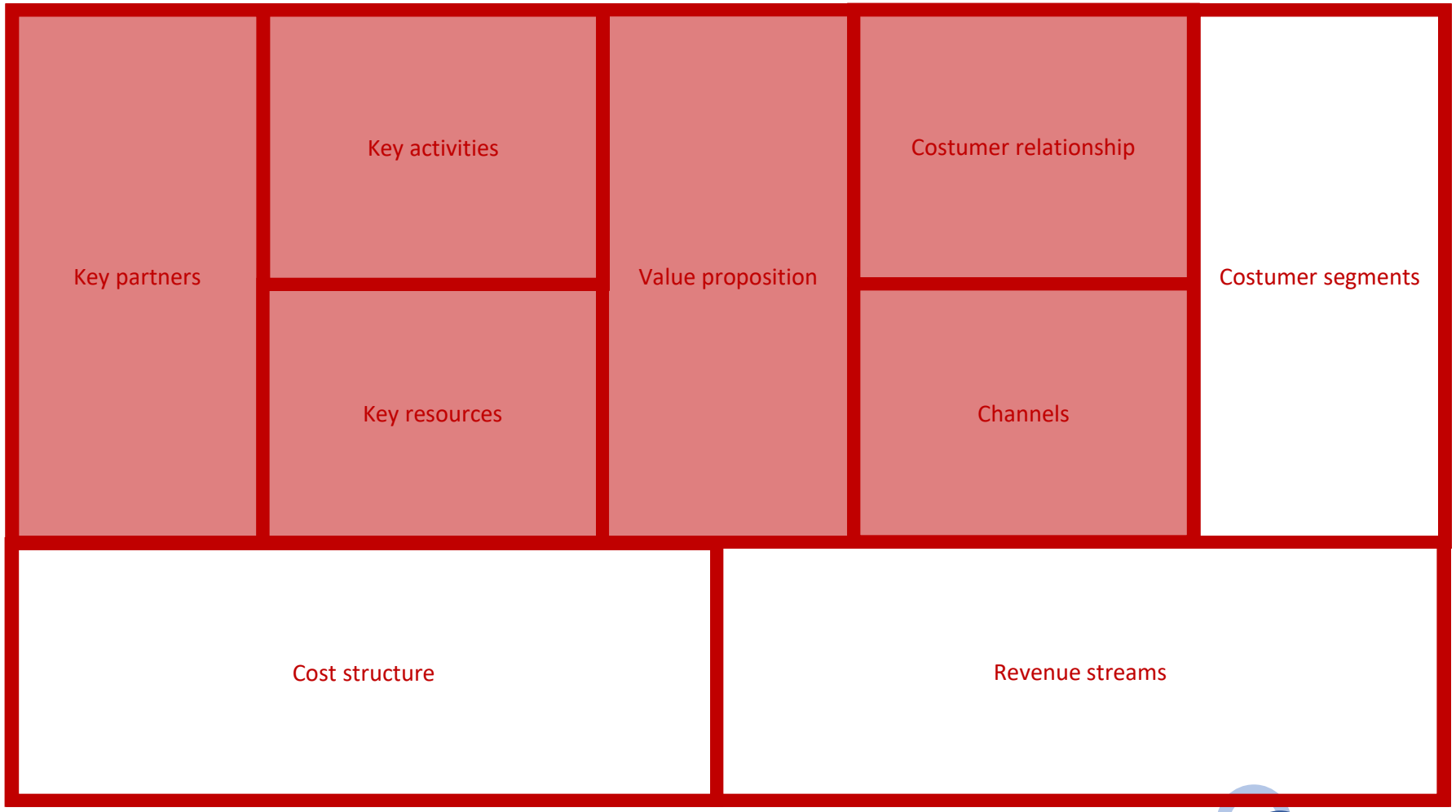
Obtained market fit



Place it back into the business model canvas



Business model canvas - managers



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MPiE

Questions?

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