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# Introduction to Operations Management

A Bilingual Business Course covering 12/1: Produktion für Berufliche Gymnasien

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### Preface

Introduction to Operations Management covers all contents of the Hessian curriculum for vocational schools, business studies, Q1, 12/1 Produktion.

It provides a basic insight into various topics related to operations management.

Although there are plenty of books about Operations Management<sup>1</sup> there is a lack of material that systematically covers the contents laid down in the Hessian Curriculum. This was the motivation to write this book. It is based on the experiences I made when teaching bilingual business at Peter-Paul-Cahensly Schule in Limburg, Germany, for the first two times. The book was also used to prepare our first students for their A-Level exams.

Thanks to my students, I was able to develop and collect material that works in class.

This is why I would like to thank both classes.

I also want to say 'thank you' to my colleagues

Dr. Hanno Egner, who was kind enough to do the proofreading and to provide valuable suggestions

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Should you have additional suggestions or ideas to improve the book please do not hesitate to contact me via email (mariaschickel@yahoo.de).

Maria Schickel, May 2017

<sup>&</sup>lt;sup>1</sup>Bozarth, Cecil C.: Introduction to Operations and Supply Chain Management, 3<sup>rd</sup> edition, 2012. Ebel, Bernd: Produktionswirtschaft, 8<sup>th</sup> edition, Ludwigshafen 2002.

Falb, Rudolf H.: Betriebswirtschaftslehre mit Rechnungswesen, 2. Auflage 2004, Troisdorf. Hayes, H., Park, A. and Ryan D.: GCSE Business Studies, Complete Revision & Practice, Newcastle upon Tyne 2009.

Hüttel, Klaus: Produktpolitik, 3rd edition, Ludwigshafen 1998.

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### P: 1-2 1. Introduction to Operations Management

What is it? Operations management is the business organization that is responsible for **planning**, **coordinating**, and **controlling** the resources needed to provide products and services for a company.

#### What is its Place in the Organization Chart?



Operations can be seen as the central part – or the heart - of a company. Marketing informs about the demand - operations decide if additional funds are needed to satisfy the reported demand. If so, finance is needed to provide the funds necessary to get ready to produce or to provide the service demanded.

#### What is the Role of Operations Management?

Operations Management<br/>transforms input to<br/>output.Inputs are resources<br/>such as people, facilities,<br/>technologies and<br/>materials.Outputs are goods and<br/>services.In the transformation<br/>process inputs get<br/>transformed into outputs.<br/>Performance information

and customer feedback serve as a control to maintain a high standard of goods and/or services.

This principle of **'Input – Transformation – Output'** can be applied to the entire production process as can be seen in the following example:

A car producing company may use sheet metal as an input. The transformation is a stamping process and the output is a car part.



This car part can be used as the input of the next transformation which may be a subassembly resulting in e.g. a door (= output)



The door may be the next input, the next transformation process the attachment of the door to the body and the output would be the car.

input	assembling	output	input	attaching	output
car part		door	door		car
			third st	ep in the production	on process

We can use the above subdivisions to illustrate operations or production processes from the beginning to the end of the manufacturing process.

#### Words you should know

operations management	Produktion
organization chart	Organisationsplan
equipment	Ausrüstung
cash flow	Barmittelstrom
current assets	Umlaufvermögen
capital investment	Investition im Anlagenvermögen
facility	Anlage, Einrichtung
sheet metal	Blech
to stamp	pressen
to assemble	zusammenbauen

### P 8 2.3.1. Job Redesign

Employees normally spend more than two thousand hours a year at work. If the job is boring or unpleasant the employee probably won't be motivated to perform at a very high level. Many companies practice a policy of job redesign to make jobs more interesting and challenging. Common strategies include job rotation, job enlargement, and job enrichment.



#### Job Rotation

Specialization leads to more efficiency because workers get very good at doing certain tasks. However, repeating the same task day in and day out gets easily boring. The practice of job rotation allows employees to rotate from one job to another on a systematic basis. A worker at an assembly line, for example, might rotate and thus learn a lot of jobs in his department. This gives him a better understanding of the company's operations and goals. A hotel might rotate an accounting clerk to the check-in desk for a few hours each day to add variety to the daily workload. Rotated employees develop new skills and gain experience that increases their value to the company. Cross-trained employees can fill in for absentees, thus providing greater flexibility in scheduling.

#### Job Enlargement

Instead of a job in which workers perform just one or two tasks, job enlargement aims at jobs with many different tasks. In theory, workers are less bored and more highly motivated if they have a chance to add tasks at similar skill levels. The job of a sales clerk, for example, might be expanded to include packaging items for shipment. The additional duties would add variety without bringing more complicated tasks about.

#### **Job Enrichment**

Whereas in *Job Enlargement* only similar tasks are added, *Job Enrichment* is the practice of adding tasks that increase both responsibility and opportunity for growth. It provides the kinds of benefits that, according to Maslow, contribute to job satisfaction: stimulating work, sense of personal achievement, self-esteem, recognition, and a chance to reach your full potential.

### P 12 **3. Cost Focus**

### 3.1. The Behavior of Different Kinds of Costs

The behavior of costs refers to the way different types of production costs change when there is a change in level of production.

There are three main types of costs according to their behavior:

#### **Fixed Costs:**

Total Fixed costs do not change with the level of activity. These costs will incur even if no units are produced. Examples for fixed costs are: rent, maintenance if it is based on a contract, depreciation, interest, etc.

Fixed costs per unit decrease with increase in production. This fact is also called **fixed cost degression**. If a huge number of units are produced the fixed costs per unit get close to zero. This is why fixed cost degression is also referred to as '**Law of Mass Production'**.

The following table illustrates fixed cost degression:

total fixed cost	\$100,000	\$100,000	\$100,000
units produced	1,000	50,000	100,000
fixed cost per unit	\$100	\$2	\$1



#### Variable Costs:

Variable costs change with the number of parts produced. Examples for variable costs are material (one chair needs one seat, 10 chairs need ten seats) and wages (for one chair a worker needs 15 minutes to assemble it, he needs 15 minutes x 10 to assemble 10 chairs).

This is why variable costs change in direct proportion to the level of production. This means that total variable costs increase when more units are produced and decrease when fewer units are produced. If nothing is produced there are no variable costs.

P	1	Λ	•
		Ξ.	

revenue	Umsatz
to assemble	zusammenbauen
mixed costs	Mischkosten
base rate	hier: Grundgebühr

### 3.2. The Break Even Point

Every person starting a new business asks, "How many products have to be sold to make a profit?" Established companies that have had to experience rough years might have similar questions. The break-even analysis provides a method that may help to answer those questions and to provide some insight as to how profits change as sales increase or decrease.

At the center of the break even analysis is the relationship between **cost** and **revenue**.

**Revenue** is the amount of money earned by providing services or selling products.  $(p \times x)$ 

Costs can be fix or variable.

Variable costs only occur when goods are produced.  $(c_v \times x)$ 

**Example:** To produce this funny chair you only need three parts: Back, seat and foot. These parts are needed for every chair. If no chairs are produced, no parts are needed.

We further assume that the back of the chair costs 3, the seat 3 and the foot 4. This means: Material cost of this chair is 3 + 3 + 4 = 10.



In addition to the parts an experienced worker needs 6 minutes to assemble the chair. The hourly wages the experienced worker gets are \$24. 6 minutes are one  $10^{\text{th}}$  of an hour, which means the labor-cost per chair is  $24 \div 10 \rightarrow $2.40$ . Thus the variable cost for our chair is \$10 + \$2.40 = \$12.40.

**Fixed costs** occur all the time no matter if production is running or not. They are not dependent on the level of goods or services produced by the business.  $(C_f)$ 

**Examples** for fixed costs are the rent that has to be paid for the production building, maintenance, leasing rates, interest, depreciation, salaries etc. Fixed costs are calculated as a block. Let's assume we have fixed costs of \$12,400 for our chair production.

**Cost function:** Using our fixed and variable costs we can set up the following cost function:

C(x) = 12.40x + 12,400 (x symbolizes the number of chairs produced)

Let us further assume that the retail price of each chair is \$24.80. The corresponding revenue function is:

**R(x) = 24.80x** (x symbolizes the number of chairs sold)

### P 28 3.9. Additional Orders and Price Floors

The planned production program and the planned operational result normally cover the fixed costs (see previous assignments). So, if a company gets an additional order, the only thing that has to be done is, to check if the offered price is higher than the variable cost per unit. If this is the case, every additionally sold product increases the operational result by the difference between price and variable costs ( $p - c_v$ ). If the price the prospective buyer wants to pay equals the variable costs, the planned operational result will not change. If the price is less than the variable costs the offer should be rejected because its acceptance would change the planned operational result for the worse.

### **Price floors**

For a very short time the minimum price a producer can accept equals the variable costs. In this case the variable costs are covered, but the fixed costs are not. This is why the **short-term price floor equals variable cost** ( $p = c_v$ ). In the long run no company can exist if a part of the costs is not covered.

In the long run all costs have to be covered. This means: the long-term price floor equals fixed costs plus variable costs divided by the number of products produced (p= ( $C_f + C_v$ ) ÷ n).

#### 22: Additional Orders and Floor Prices

Suppose operation planning has released the following production program:

number of drilling machines planned:	12,000
capacity utilization:	75%
sales price:	\$195
fixed costs:	\$450,000
variable costs (12,000 units):	\$1,140,000

- 22.1 Calculate the planned operational result
- 22.2 Which floor price could be accepted
  - for a very short time?
  - for a longer time?
- 22.3 The company owner's best friend places an additional order. He wants to buy 5,000 drilling machines and offers to pay \$110 for each.
  - Please check if there is enough capacity left.
  - The friend is a flexible person what is the new production program.
  - He insists on 5,000 machines or nothing.
  - What would the operational result be and what should the company do?

### P 30 4. Adaptation to Changes in Production

A company may be confronted with the situation that more than 100% of their capacity is needed to complete an order but a decline is not possible because the customer could order elsewhere in the future. Basically the company can choose from three different ways to adapt to the new situation:

- They can decide to work overtime. This way to adapt to a workload of more than 100% capacity is called time related adaptation. The number of hours worked is extended, the overtime hours usually cost the normal wage rate plus an overtime premium of usually 50% of hourly wages.
- Intensity adaptation. If this way to adapt to an increased workload is chosen, the speed at which a machine runs is increased. Intensity adaptation causes additional costs.
- The third possibility to adapt to an increased workload is the so called quantitative adaptation. In this adaptation additional machines are used to deal with the situation.
- A further possibility could be to choose a combination of time related and intensity adaptation.

A company may also have to decide how to cut down production because a customer canceled an order or because a recession which goes hand in hand with less demand. Again the company can choose different ways to adapt to the new situation:

- They can decide to work reduced working hours. This way to adapt to a decreasing workload is also called time related adaptation. The number of hours worked is reduced, the reduced hours usually cost the normal wage rate plus a compensation to enable the worker to keep up the standard of living.
- Intensity adaptation. If this way to adapt to a decreased workload is chosen, the speed at which a machine runs is reduced. This also causes additional cost because the machine cannot work at the optimal speed at which costs are minimal.
- The third possibility to adapt to a reduced workload is the so called quantitative adaptation. Here existing machines are switched off.
- A further possibility could be to choose a combination of time related and intensity adaptation.

The decision which form of adaptation is realized depends on the time frame of the change. If the change in production is only on a short-term basis, time related adaptation or intensity adaptation or a combination of both should be preferred. Is the change permanent, the quantity adaptation is the best alternative.

adaptation, to adapt	Anpassung, anpassen
time related adaptation	zeitliche Anpassung
overtime hours, overtime premium	Überstunden, -zuschlag
intensity adaptation	intensitätsmäßige Anpassung
quantitative adaptation	quantitative Anpassung
to cancel an order	einen Auftrag stornieren
compensation	Ausgleich

Words you should know

### P 42 5. Quality Focus

## 5.1. Product Life Cycle<sup>2</sup>

The product life cycle was developed by the economist Raymond Vernon in 1966. It is still a widely used model in economics and marketing.

Products enter the market and gradually disappear again. According to Raymond Vernon, each product has a certain life cycle that begins with its development and ends with its decline.

There are five stages in a product's life cycle: "development", "introduction", "growth", "maturity" and "decline". As sales cannot start before the "introduction" stage, the product life cycle is often said to have the four stages: "introduction", "growth", "maturity" and "decline". The length of a stage varies for different products, one stage of the product life cycle may last some weeks (e.g. Pokemon Go) while others even last decades (VW-Beetle or Coca Cola). The life span of a product and how fast it goes through the entire cycle depends on market demand and how marketing instruments are used.

The graph below shows a Product Life Cycle. Sales start in the second stage, when the product enters the market. As the development of new products is very expensive the profit line is negative at first because there are costs but no revenue during product development.

The picture shows the product life cycle. The two graphs (sales and profit) give an idea of a product which starts its "life" with the development phase and goes through all phases until it reaches the last phase, the decline.<sup>3</sup>



<sup>2</sup> http://www.toolshero.com/marketing/product-life-cycle-vernon/

<sup>3</sup> <u>https://atitus707.wordpress.com/product-life-cycle-stages-and-strategies/</u>

### 5.2. BCG Matrix

The BCG matrix or Boston Consulting Group Matrix is a valuable tool to help companies to analyze their portfolio (all the products they produce) and understand their potential.

It was created by Bruce Henderson of the Boston Consulting Group in 1968 and aims to identify high-growth prospects by categorizing the company's products according to growth rate (in %) and relative market share (relative to the market share of the most successful competitor). By optimizing positive cash flows in high-potential products, a company can take advantage of growth opportunities.

#### How to set up a BCG Matrix

To set up a BCG matrix, companies gather information about relative market-share and growth-rate of their products.



Relative market share is written on the horizontal axis, the vertical axis shows the growth rate of the individual products.

Products which have entered the market and are on their way to get known by the customers have a high growth rate but a small relative market share. To arouse customer awareness it takes high investments in the promotion of these products. In this phase it is not clear yet whether the product will continue growing and gaining a bigger market share. This is why such a product is called **question mark** (or sometimes problem child). If they are successful and grow rapidly they do have the potential to turn into stars. Companies should invest in question marks if the product has potential for growth, or drop if it does not.

A successful question mark turns into a **star**. Stars have a high relative market share and at the same time a high growth rate. They are highly profitable products and thus generate cash-flow which is however mostly used for promotion to help making the product even more successful. Stars can eventually become cash cows if they sustain their success until a time when the market growth rate declines.

P 47

# P 535.4 Total Quality Management

What is it?	Focus on the Customer TQM Continuous Improvement Total Starff Participation
	Total Quality Management (TQM) is a management philosophy that aims at integrating all organizational functions (marketing, finance, development, engineering, production, customer service, etc.) to focus on meeting customer needs.
	TQM defines an organization as a series of successive processes. Organizations must try to continuously improve these processes by using the knowledge and experiences of workers. The simple objective of TQM is
	"Do the right things, right the first time, every time."
	TQM is variable and adaptable. Although it was originally designed for manufacturing operations, and for a number of years only used in that area, TQM is now seen as a management tool, just as applicable in service and public sector organizations.
Which are typical features of TQM?	<ul> <li>There are a number of typical features that are vital for TQM:</li> <li>meeting customer requirements <ul> <li>reducing development cycle times</li> <li>just in time</li> <li>reducing product and service costs</li> <li>employee involvement and empowerment</li> <li>focus on processes</li> <li>continuous improvement</li> </ul> </li> </ul>
	TQM can be practiced in all activities, by all personnel, in manufacturing, marketing, engineering, sales, purchasing, human relations (HR), etc. <sup>4</sup>

<sup>&</sup>lt;sup>4</sup> Hyde, A. (1992). "The Proverbs of Total Quality Management: Recharting the Path to Quality Improvement in the Public Sector." *Public Productivity and Management Review*, 16(1), 25-37.

### P 61 6.Inventory Management

# 6.1. Stock Control Chart

Inventory management is the way a company controls its stock of material necessary for production. If the system used is effective there will always be enough parts available for production without holding too much stock. There are different methods to control stock. The oldest and traditional methods are stock control charts.

#### Stock control chart



A typical chart is shown on the left. The vertical axis shows the inventory level, the horizontal axis shows the time. When an order is received, stock can be filled up to the maximum order quantity. In the following time the stock is used up, the level of stock

gradually falls from left to right (blue line). When the reorder point is reached, the next order has to be

placed. This reorder point has to be calculated carefully by multiplying the parts needed per day by the number of days it takes to receive the next order. The time between placing and receiving the order is called lead time, or time to process the order and make the delivery. If the order is placed too late or the delivery takes too long, there will be not enough stock to continue production. This is why many companies keep a minimum stock level which is also known as buffer stock.

The chart gives an idea of how stocks get filled up, used up and replenished, however it does not show a realistic stockholding. In reality a constant usage of stock is the exception. The slope of the stock level line will rather vary. Sometimes it might be steeper or shallower than shown in the graph.

#### 41: Stock Control Chart:

The order quantity of raw material is 1,000 units per ordering-event, the daily consumption of raw material is 200 units, the supplier needs two days to process the order and to deliver the raw material.

Draw a detailed, traditional inventory chart that reflects the situation described.