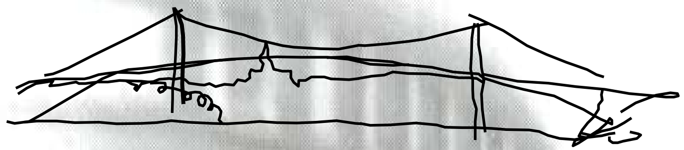

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Inventory planning

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Safety stock

- The **safety stock** (also calles minimum or resource inventory) helps to protect the ongoing operation of a company against demand, supply and inventory uncertainties..
- It depends on the procurement time (replenishment time) and the average daily consumption
- The own safety stock also depends on the safety stock of the supplier (see below)

Supplier		Customer
Delivery time depends on safety stock	➔	Safety stock depends on replenishment time

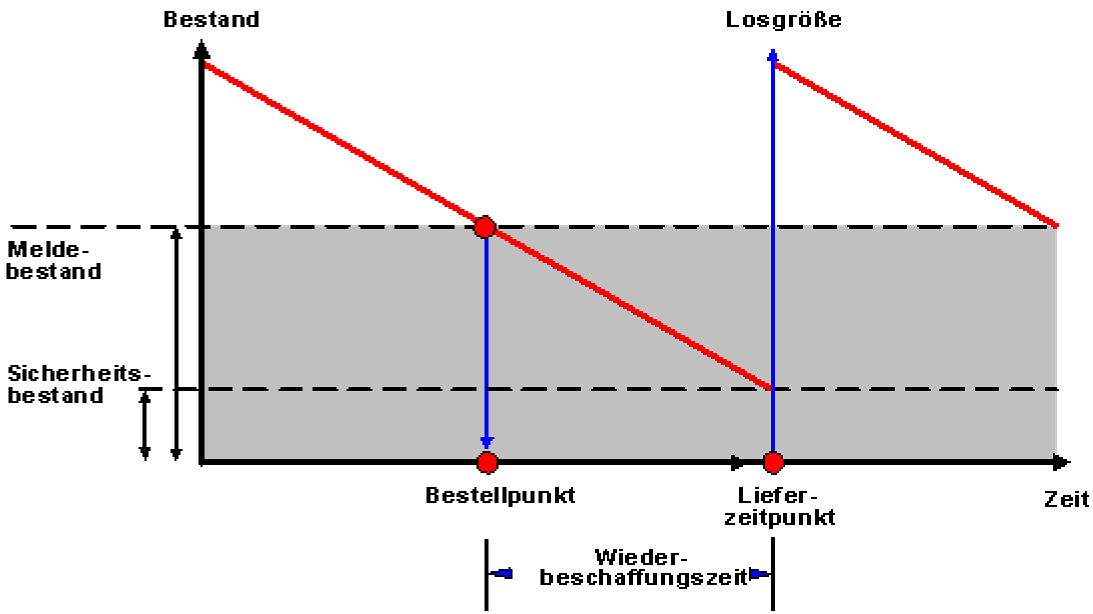
Delivery time = replenishment time

Source: Tempelmeier

Ssafety stock

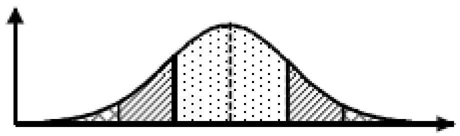
The safety stock covers *3 uncertainties:*

- ☐ *Uncertainty in demand* (identified demand does not comply with daily demand)
- ☐ *Uncertainty in delivery* (target delivery time does not comply with actual delivery time)
- ☐ *Uncertainty in inventory* (book inventory balance and inventory do not match)



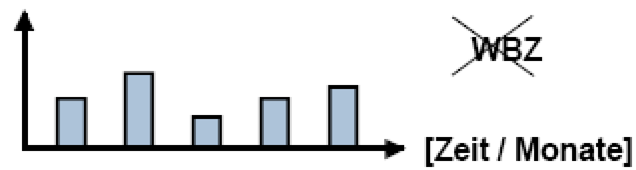
Outward stock movement distribution

- Only consideration of normal distribution
- High effort for the schedulers to determine the type of distribution



Data base

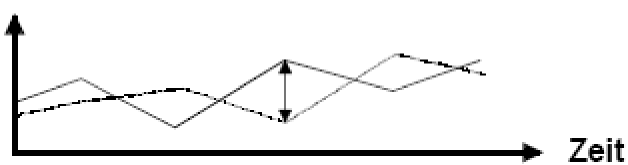
- Data only available on a monthly basis
- Article specific replenishment time is not considered



Causes for safety stocks

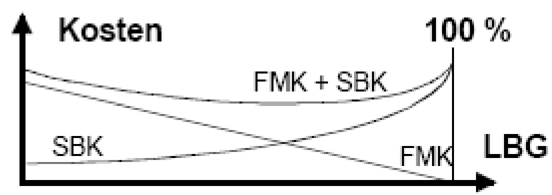
Forecasting quality

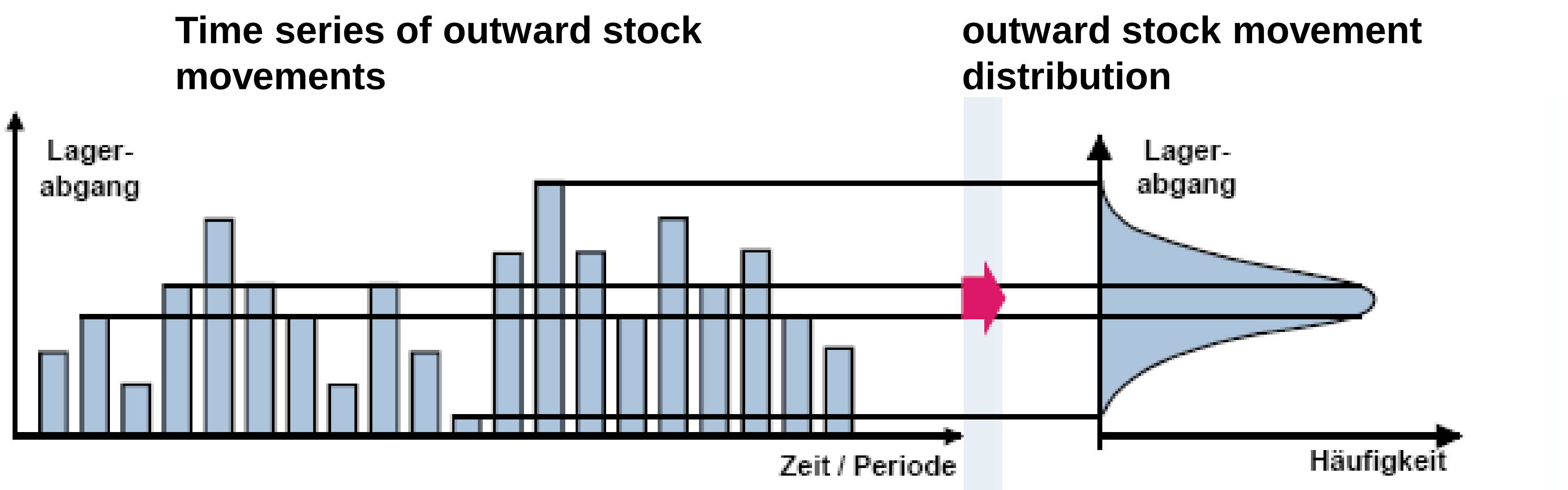
- No differentiated application of appropriate forecasting methods
- Regularity/Unsteadiness of demands

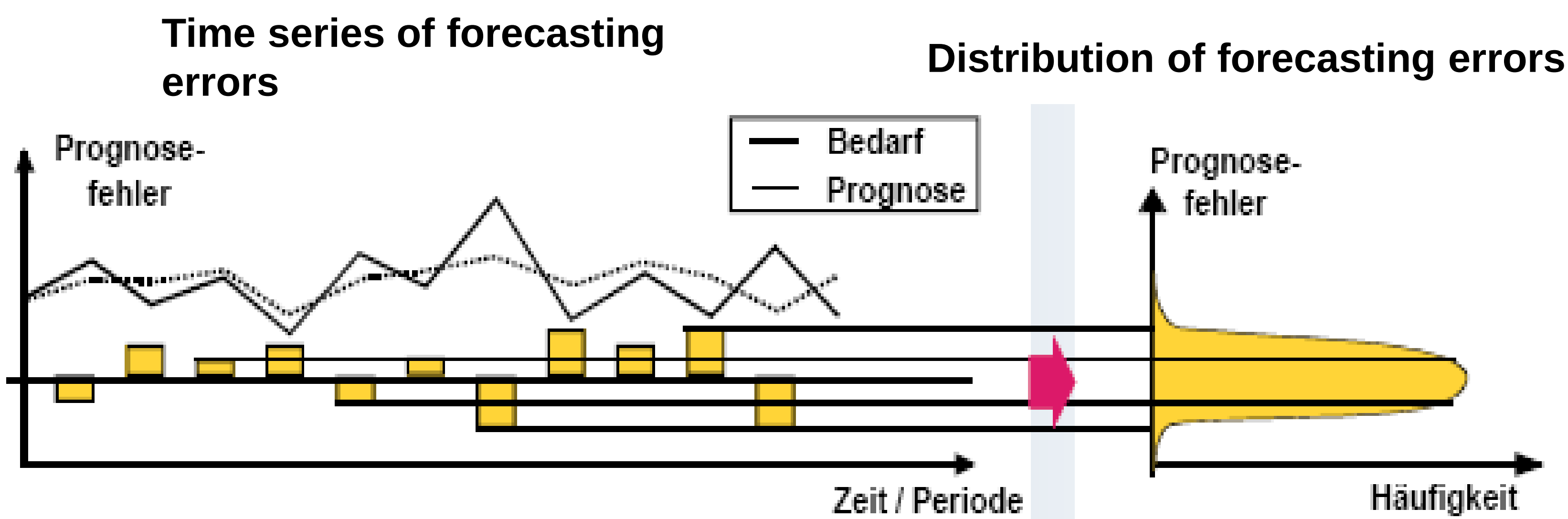


Cost transparency

- Choice of high degrees of readiness for delivery
- Out-of-stock cost only assumed







Quelle: RWTH Aachen

Methods for the caluculation of safety stock

Calculation of safety stocke by means of replenishment time

- General *practical formula*
- *Coverage of additiolnal consumption and delays in delivery* by safety stock
- *Coverage of the average consumption* during replenishment time

Calculation of safety stocke by means of service degree

- Calculation of safety stock from *service degree* and *standard deviation*

General practical formula

- Safety stock is to be **1/3 of the consumption** during normal replenishment time
- SB = 1/3 * consumption

Coverage of additional consumption und delays in delivery by safety stock

- In safety stock are considered both addtional consumption and delays in delivery
- SB = replenishment time * additional consumption + delays in delvery * (average + additinal consumption)

Coverage of the average consumption during replenishment time

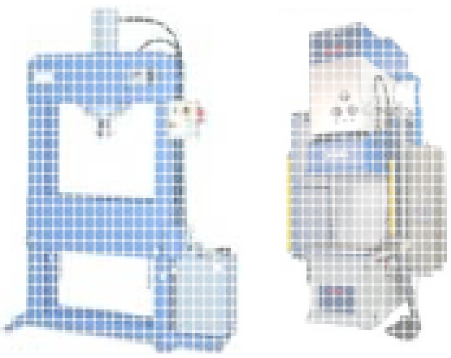
- Safety stock covers the average consumption during replenishment time
- SB= Replenishment time* average consumption/day

Replenishment time

- The determination of the safety stock is closely connected the knowledge of replenishemt time , thus, the period the quantity of goods need from the point of time of order release until the arrival at the warehouse.

- To the replenishment time belongs the duration
  - → of administrative in-house proceeding
  - → of order acceptance and processing at the supplier
  - → of transport
  - → of control of goods received
  - → of quality control and
  - → of storing

The FIRpress GmbH is a medium-sized *mechanical and plant engineerer.* Main products are hydraulic presses. The company has about 5000 employees inland and abroad. The FIRpress GmbH is a so called manufacturer of products with variants and a global company. The storage locations structure is distributed all over Europe. Some parts are also delivered from Asia.



Quelle: RWTH Aachen

The *reorder level* in the subassembly „Hydraulic hoses“ of the FIRpress GmbH is *5000 hoses*. Last year‘s measurings gave an *average consumption of 300 hoses per day*. Currently there is an *additional consumption of about 150 hoses per day*. *The replenishment time is 12 days*. Because of the high demand for the manufacturer one has to face a *delay in deliveries of 3 days*.

Calculate the safety stock according to the three calculation methods used in practice by means of the replenishment time!

i) General practical formala:

1/3 of the consumption during the normal replenishment time:

□ **1/3 * 3600 = 1200 hoses**

ii) Coverage of addtional consumption und delays in delivery by safety stock:

Replenishment time * additional consumption + delay in delivery *(average + additional consumption)

□ **12 days * 150 hoses/day + 3 days*450 hoses/day = 3150 hoses**

iii) Coverage of the average consumption durng the replenishment time:

Replenishment time * average consumption/day

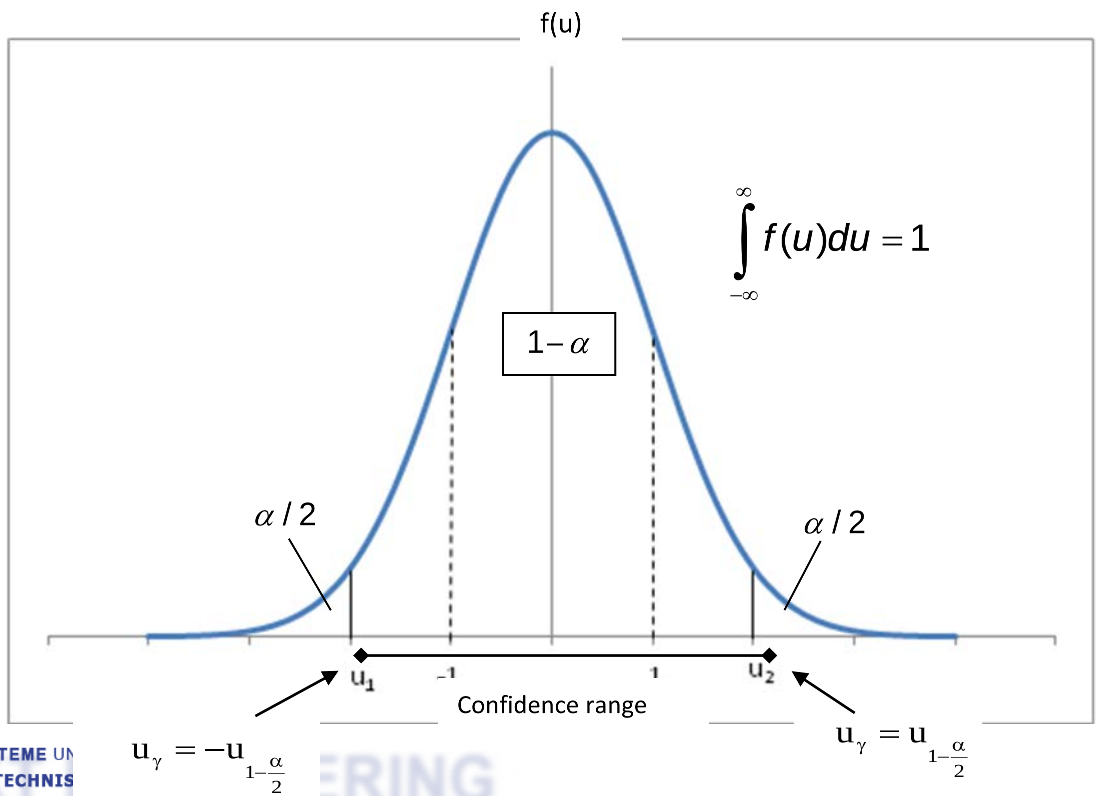
□ **12 days* 300 hoses /days = 3600 hoses**

Calculation of safetey stock from service degree

The *statistical safety s* indicates the probability for the fulfillment of the given service degree with a given distribution of article inventories.

$s = 1 - \alpha$ s is within a *confidence range.*

$\alpha = 1 - s$ the so called *probability of error α* indicates the probability that the true parameter value is outside the confidence range.



Calculation of safetey stock from service degree (cont.)

The x-coordinates u_1 and u_2 are called *quantile* of the normal distribution. Provided with an index *γ* (with γ = α, γ = 1 – α, γ = 1 - α/2) and the indication of the algebraic sign the kennzeichnen die *quantiles u_γ* mark a quantifiable part of the area under the probability curve.

Statistical safety (service degree) 95%:

s = 95% α = 1- s = 0,05

Reading example:

With a probability of error α = 0,05 is for:

$$\gamma = 1 - \alpha = 0,95 \quad \Rightarrow \quad u_\gamma = u_{1-\alpha} = 1,645$$

$$\gamma = \alpha = 0,05 \quad \Rightarrow \quad u_\gamma = u_\alpha = -u_{1-\alpha} = -1,645$$

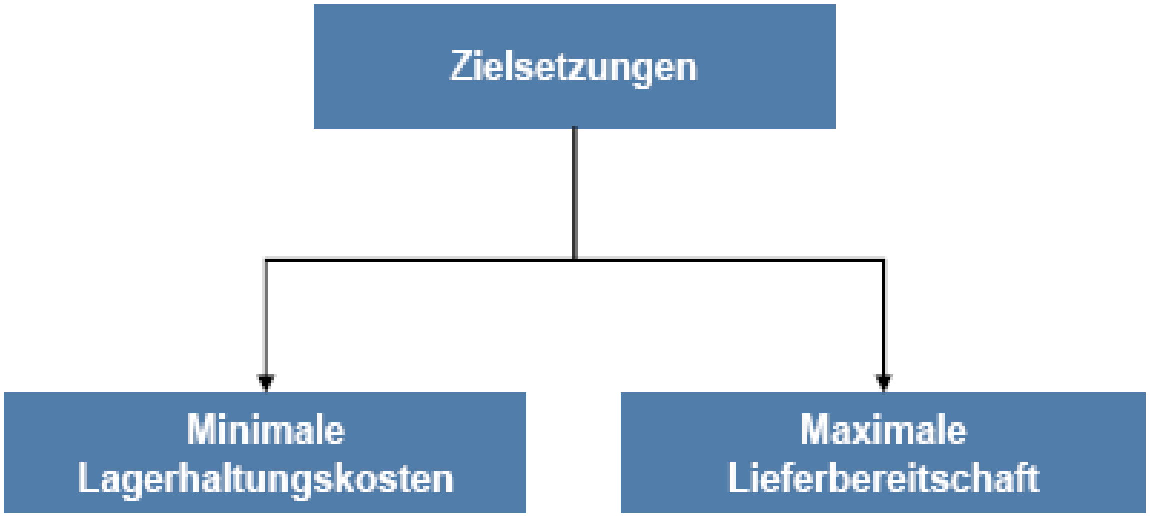
$$\gamma = 1 - \frac{\alpha}{2} = 0,975 \quad \Rightarrow \quad u_\gamma = u_{1-\frac{\alpha}{2}} = 1,960$$

γ	u_γ
0,999	3,090
0,990	2,325
0,975	1,96
0,95	1,645
0,925	1,440
…	…

For a **symmetric** interval (normal distribution!):

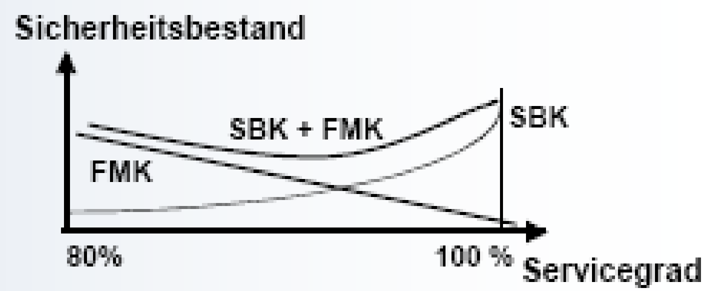
$$\gamma = 1 - \frac{\alpha}{2} = 0,975 \quad \Rightarrow \quad u_\gamma = 1,96 \text{ (aus Tabelle!)}$$

$$u_\gamma = 1,96 \approx 2,0$$ (95,4% stat. safety).



„Summe der Fehlmengenkosten und die Lagerhaltungskosten minimieren"

$$\text{Servicegrad} = \frac{\text{Anzahl sofort befriedigter Nachfragen}}{\text{Gesamtanzahl der Nachfragen}} \times 100\%$$



FMK = Fehlmengenkosten
SBK = Servicebereitstellungskosten

Quelle: RWTH Aachen

Calculation of safetey stock (service degree)

The service department of the *FIRpress GmbH* gets on average 360 orders for hydraulic hoses per year. The management allows a maximum of 7 shortfalls per year.

- ☐ The standard deviation of the orders was identified to be *σ = 37 pieces*.
- ☐ Calculate the safety stock under consideration of the service degree!
- ☐ Is the *order frequency respectively order quantity* important for the determination of the safety stock?

Berechnung des Sicherheitsbestandes (Servicegrad)

- The *service degree* adds up to: (360-7)/360 = 0,9806 ≈ 98,0%
- Probability of error: *α = 1- 0,98 = 0,02*
- With the aid of the table of the standard deviaton the errechnet sich der *safety factor* *k* calculates to: *k= 2,35*

$$\gamma = 1 - \frac{0,02}{2} = 0,99 \quad \Rightarrow \quad u_{\gamma} = u_{1-\frac{\alpha}{2}} = 2,35$$

- From this results a *safety stock SB* ***of***:
  SB = k· σ = 2,35·37 = 86,95

- The safety stock depends on the order frequency respectively order quantity. A large order quantity protects the very more against shortfalls before lapse of ordering time than a small one. Hence, one only needs a lower safety stock for one material when it is procured in lager lots because the occurence of shorfall events is then more rarely.