Optimizing Supply Chains: A Life Cycle Perspective

Ton de Kok

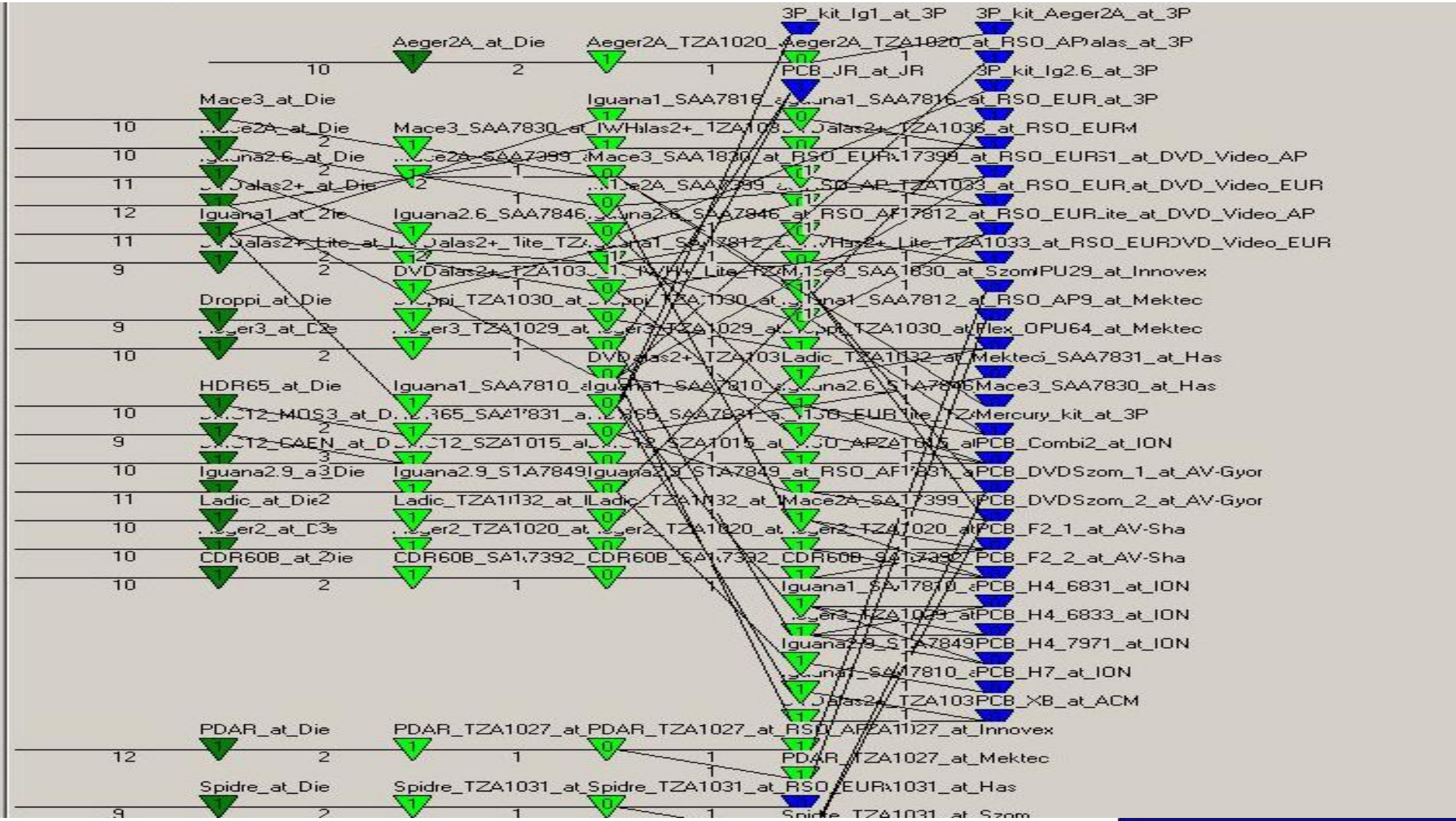
School of Industrial Engineering

Partly based on materials provided by
Geert-Jan van Houtum

Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Real-life supply “chain”



Agenda

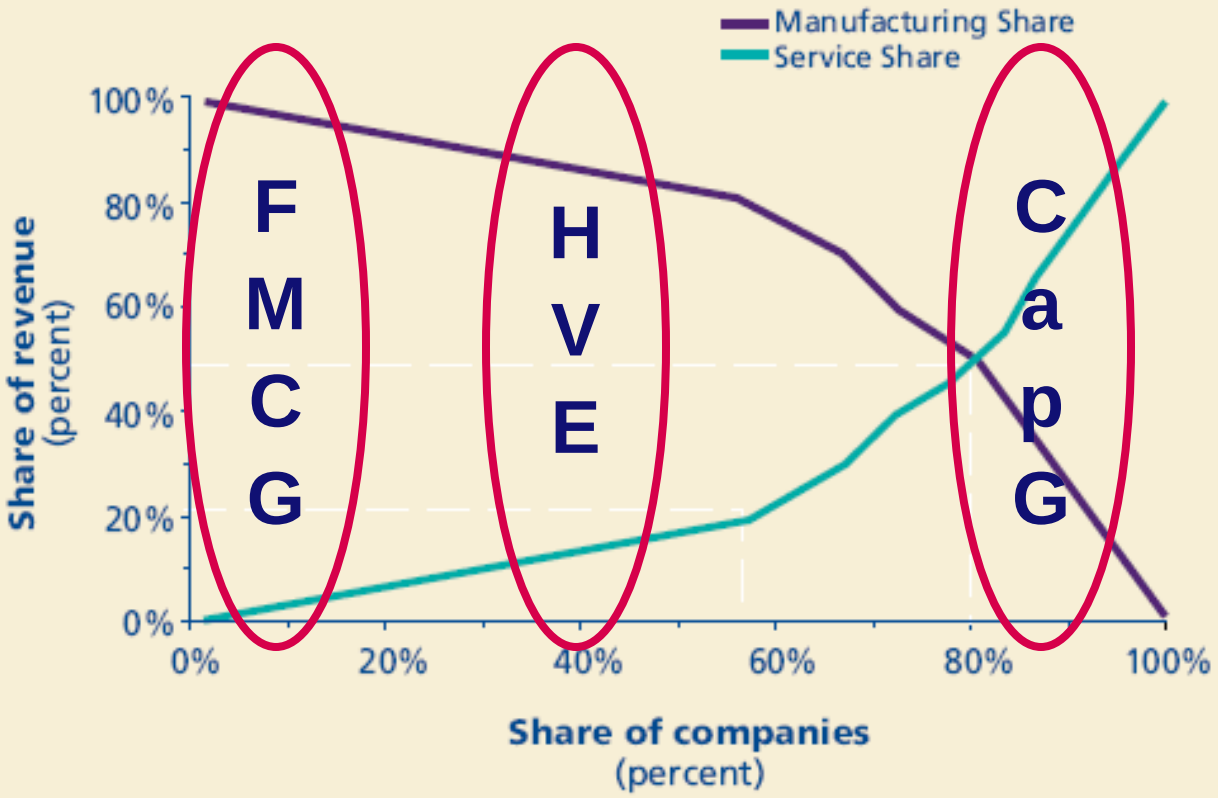
- Initial and Service Supply Chains
- Life Cycle
- Efficient Frontier
- Modeling Supply Chains
- Methodology
- Case studies
- Generic laws
- Conclusions

Initial and Service Supply Chain

- **Initial Supply Chain creates the product and sells it to the market of users and consumers**
- **Service Supply Chain supports users and consumers to ensure proper functioning of the product**
- **Initial Supply Chain supports Service Supply Chain with products and parts until the product phases out**
- **Initial Supply Chain has a web structure**
- **Service Supply Chain is predominantly divergent from a physical distribution point of view**

Figure 2: Catching up to the service revolution in global manufacturing

The average service share of total sales revenues is more than 25 percent and for many global manufacturing companies benchmarked the service share is larger than 50 percent. Yet, for more than half the companies, the service business still contributes less than 20 percent of total sales.



Source: Deloitte Research, based on the Global Service and Parts Management Benchmark Survey.

Objective of supply chain optimization

Given transformation processes to be executed and markets to be delivered,

Design and control the value network, such that operational customer service requirements are achieved, while optimally balancing internal objectives, such as ROI, profits and market share

Life Cycle and SCM

Stage	Characteristics
1. **Market introduction stage**	•Slow sales volumes to start •Demand has to be created •**Ensure availability**
2. **Growth stage**	•Sales volume increases significantly •Competition begins to increase with a few new players in establishing market •**Exploit supplier's market situation by careful ATP management and adhere to commitments**
3. **Maturity stage**	•Sales volume peaks and market saturation is reached •Brand differentiation and feature diversification is emphasized to maintain or increase market share •**Adhere to market standards concerning customer lead times and delivery reliability at minimal cost**
4. **Saturation and decline stage**	•Sales volume decline or stabilize •**Carefully empty the supply chain to avoid obsolescence**

Source: wikipedia

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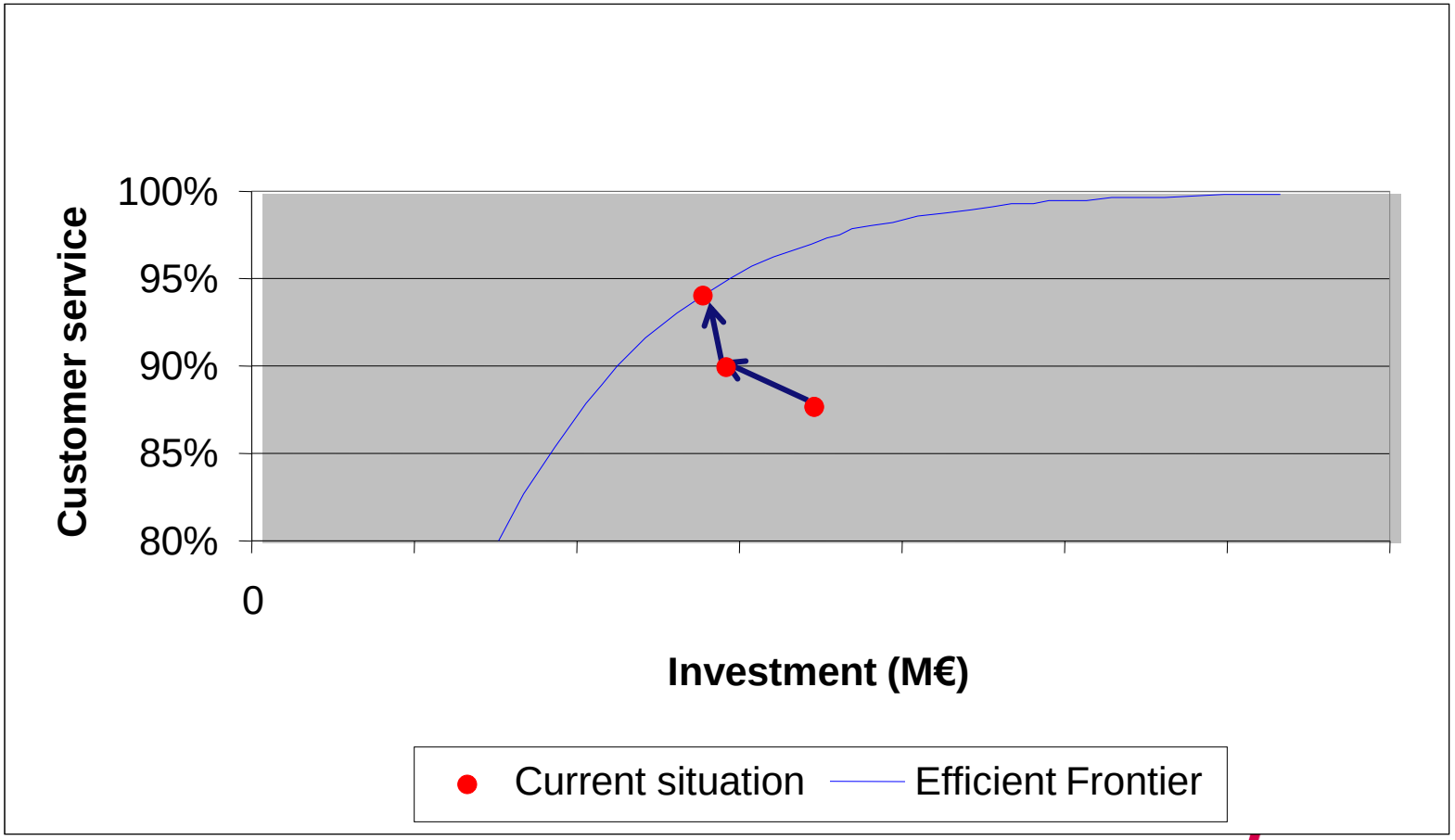
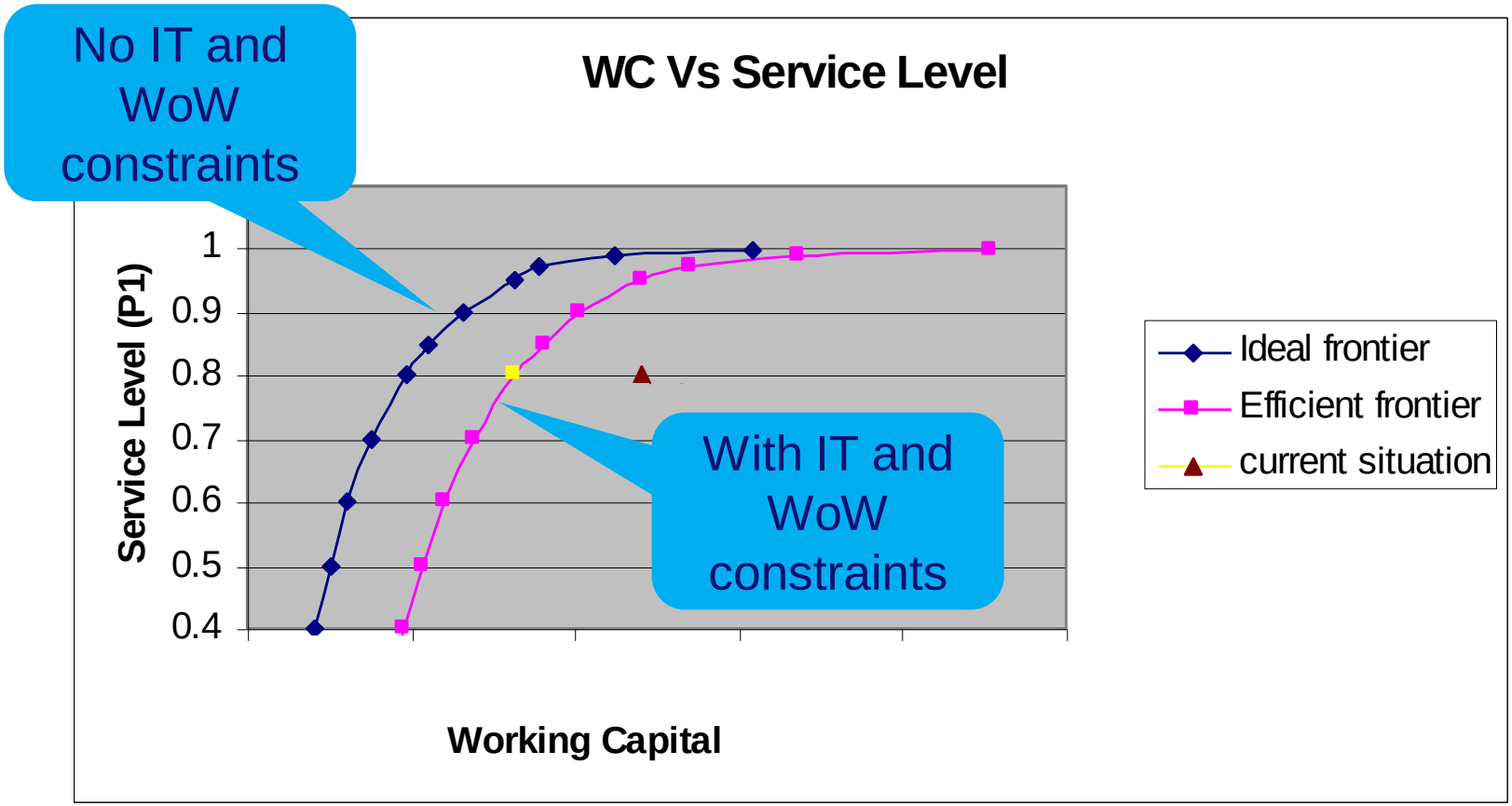
Source: wikipedia

Efficient frontier



Efficient frontier



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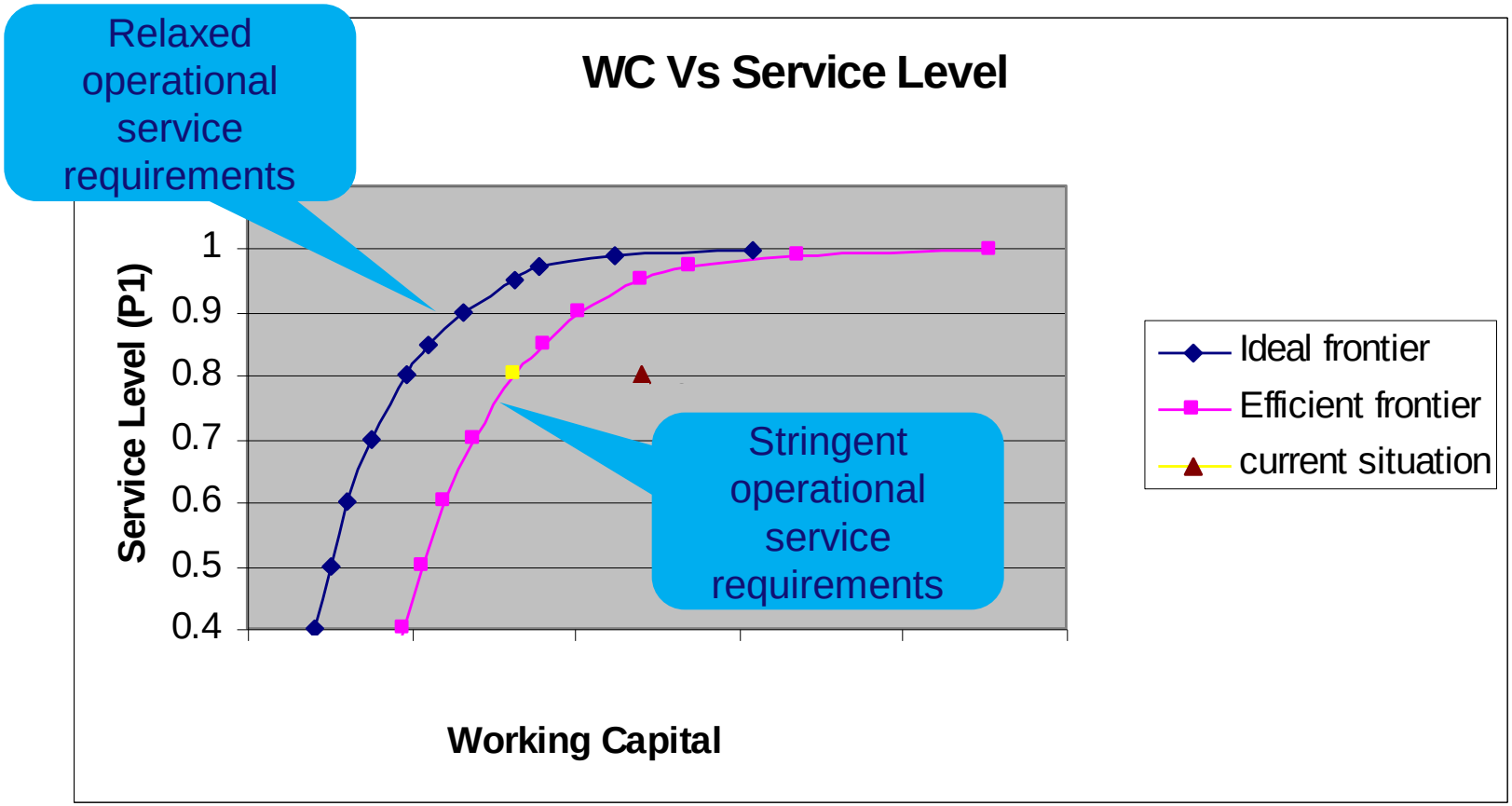


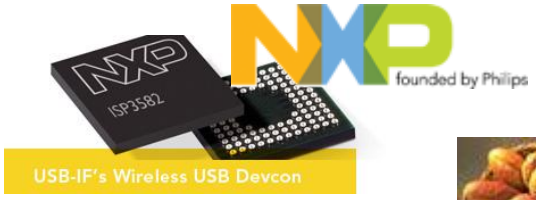
Methodology

- Characterize operational processes based on ERP data
  - Demand processes at item-customer and item-user level
    - In SSC demands result from failures
    - Means and variances
  - Manufacturing processes and distribution processes
    - Throughput times
    - Means (and variances)
- Define operational service requirements at item-customer and item-user level
  - Response time window
  - Response reliability
  - System availability
- Determine cost structure
  - Added cost of each transformation process
    - Distinguish between fixed and variable costs
  - Margin or market price
- Build a mathematical model and “optimize” case

Mathematical model

- End-item demand
  - I.i.d. in subsequent periods
  - Compound renewal
- Lead times
  - Constant
  - Stochastic
- BOM defining relationships between items
- Linear inventory holding costs
- Service level constraints or linear penalty costs
  - Equivalence of non-stockout probability and linear penalty costs under optimal policy
- (Echelon) base-stock control
- Linear rationing rules in case of shortages
- Close-to-optimal policies derived from recursive optimality equations
  - Solving general finite-horizon ruin probabilities

ISC case studies



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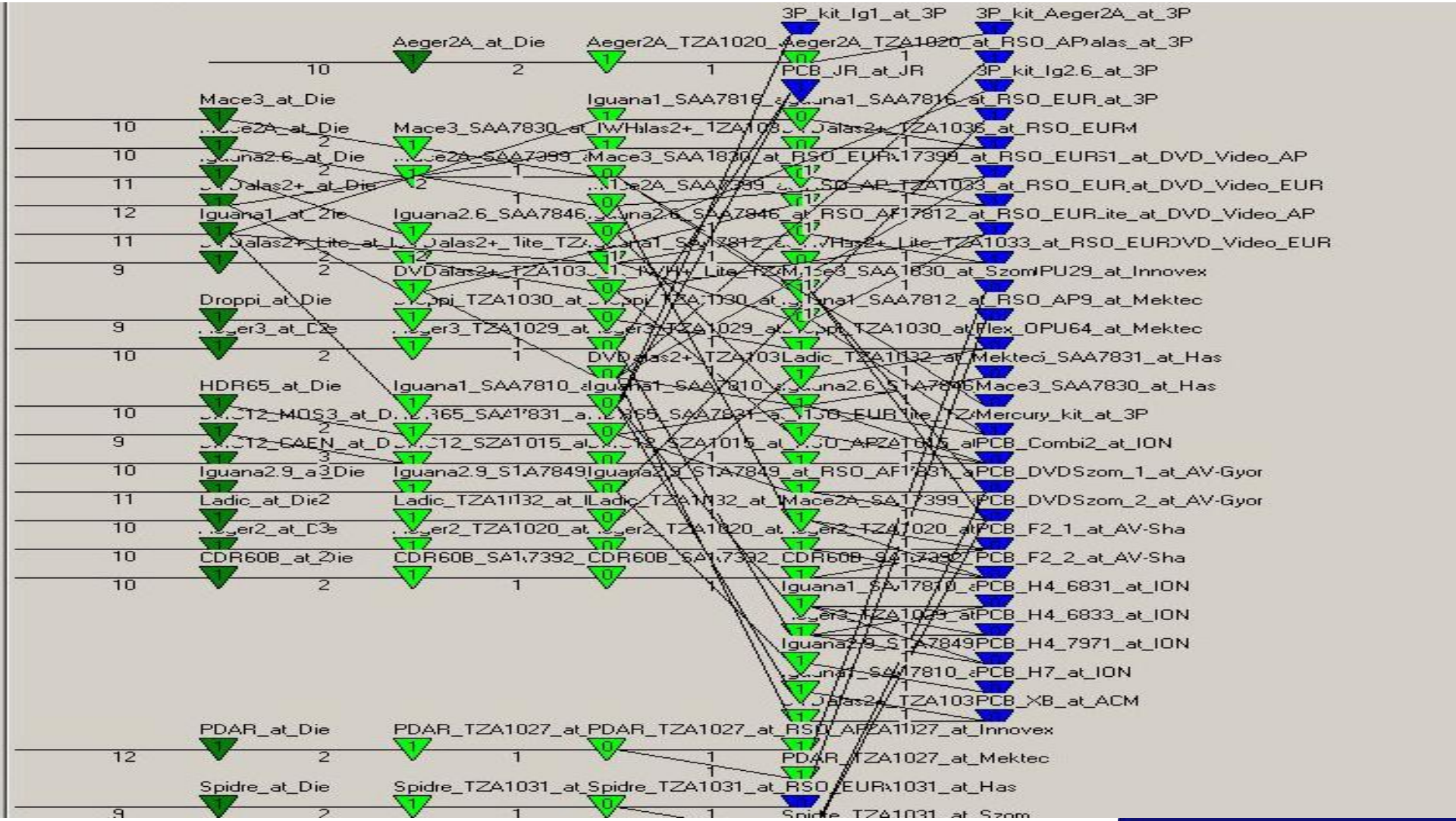
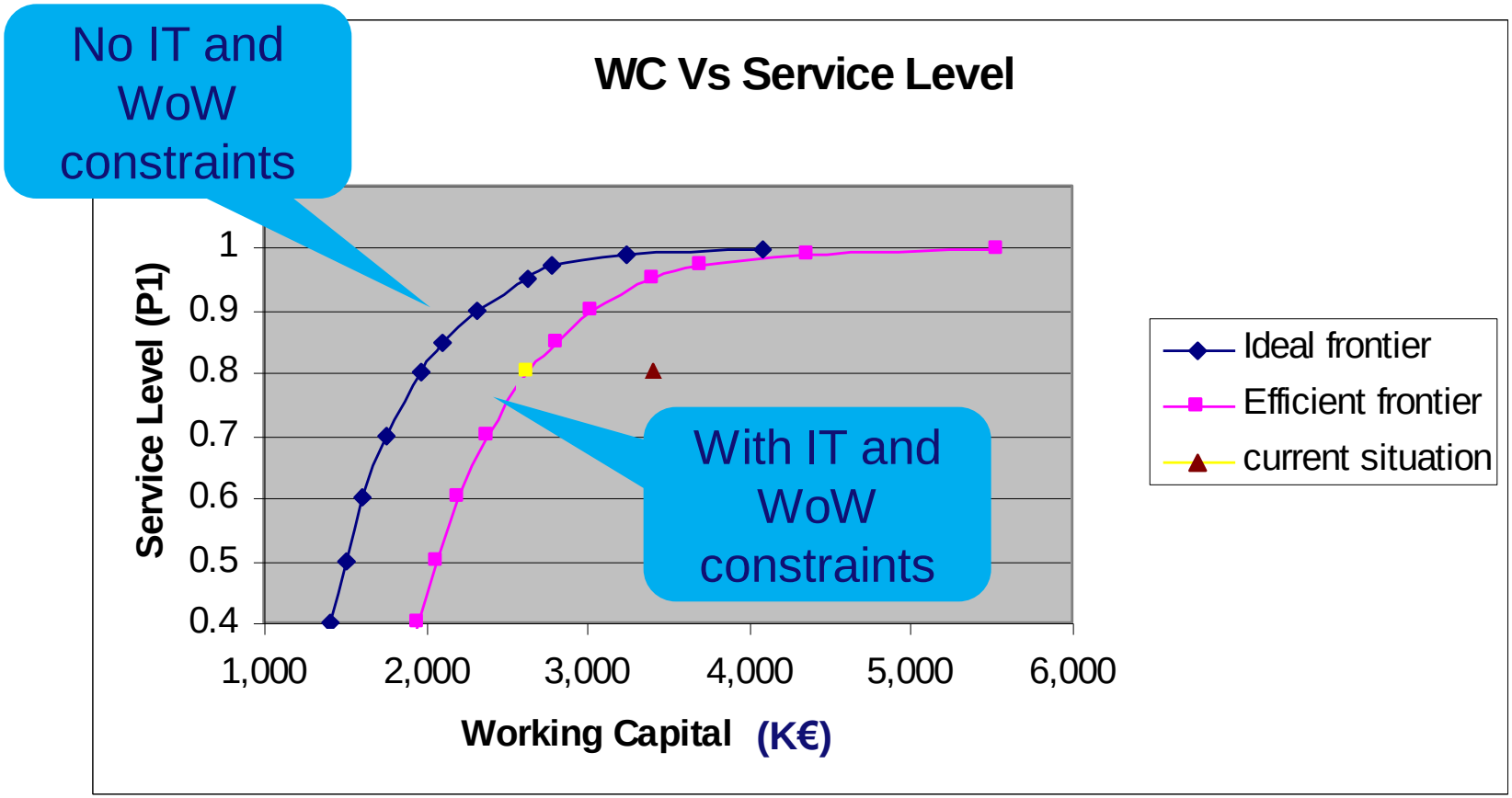
Real-life supply “chain”



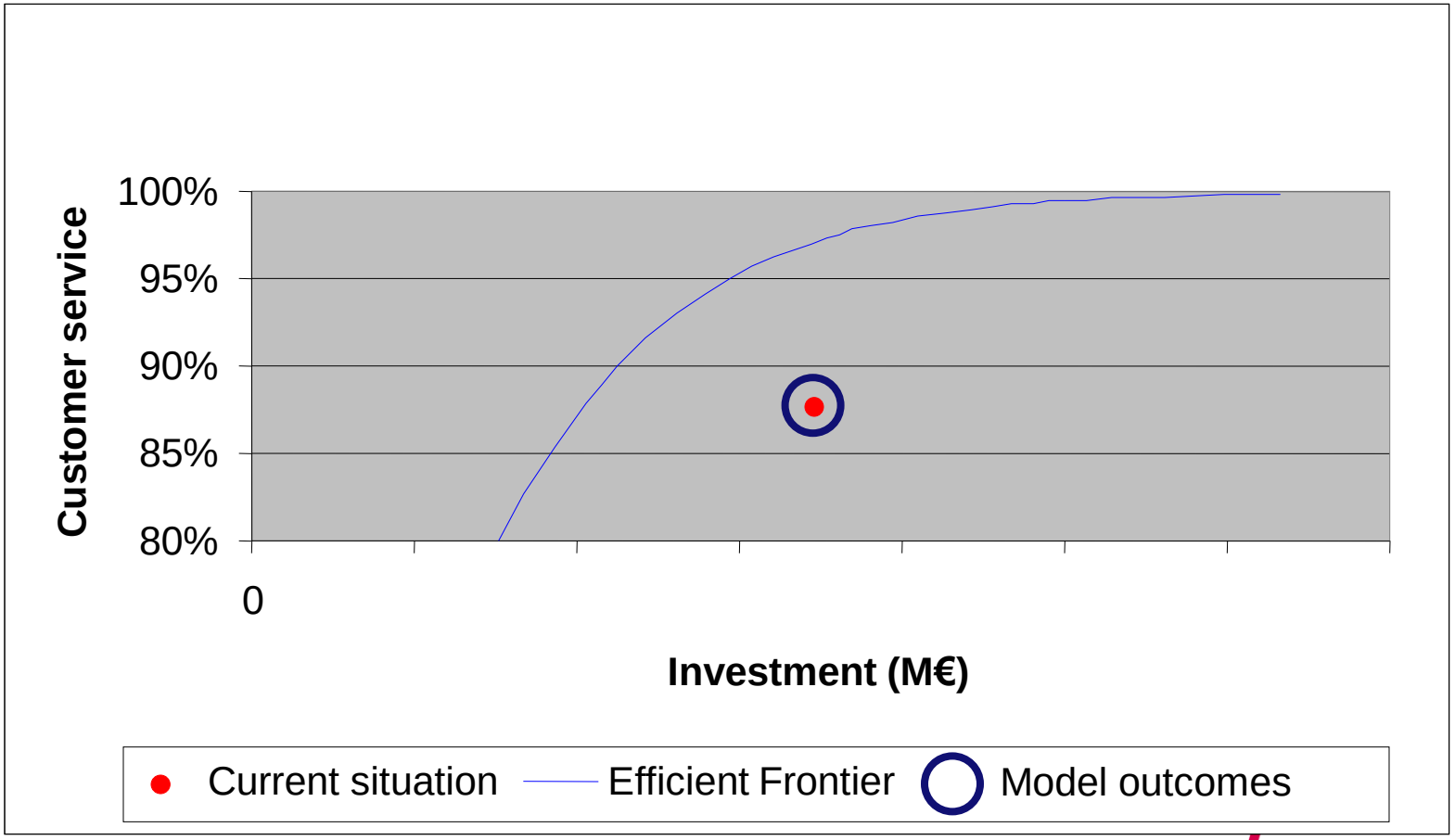
ISC high-tech case



Validation of quantitative models in OM/OR

- It is often impossible to create laboratory conditions
  - System behavior changes over time
- It is impossible to repeat a “test”
- We may borrow from medicine
  - Test animals and humans are different dynamic systems
  - Use a sample of sufficient size

Efficient frontier view



Validation methodology

- Use the same model for different systems
  - SBS applied to multiple different supply chains of different companies
- For each system gather historical data on
  - Item-customer demand proces
  - Item inventory evolution
  - Item lot-sizes or review periods
- For each system gather data about
  - Lead times
  - BOM
  - Added cost (value)
- Use these data to compute item-customer service levels
- For each system gather historical data on
  - Item-customer service level
- Compare computed and actual service levels

Mass fabrication for professional market

- **2021 items**
- **1279 item-customer combinations**
- **4899 BOM relations**
- **Cumulative lead time > 85 days**

Validation principles

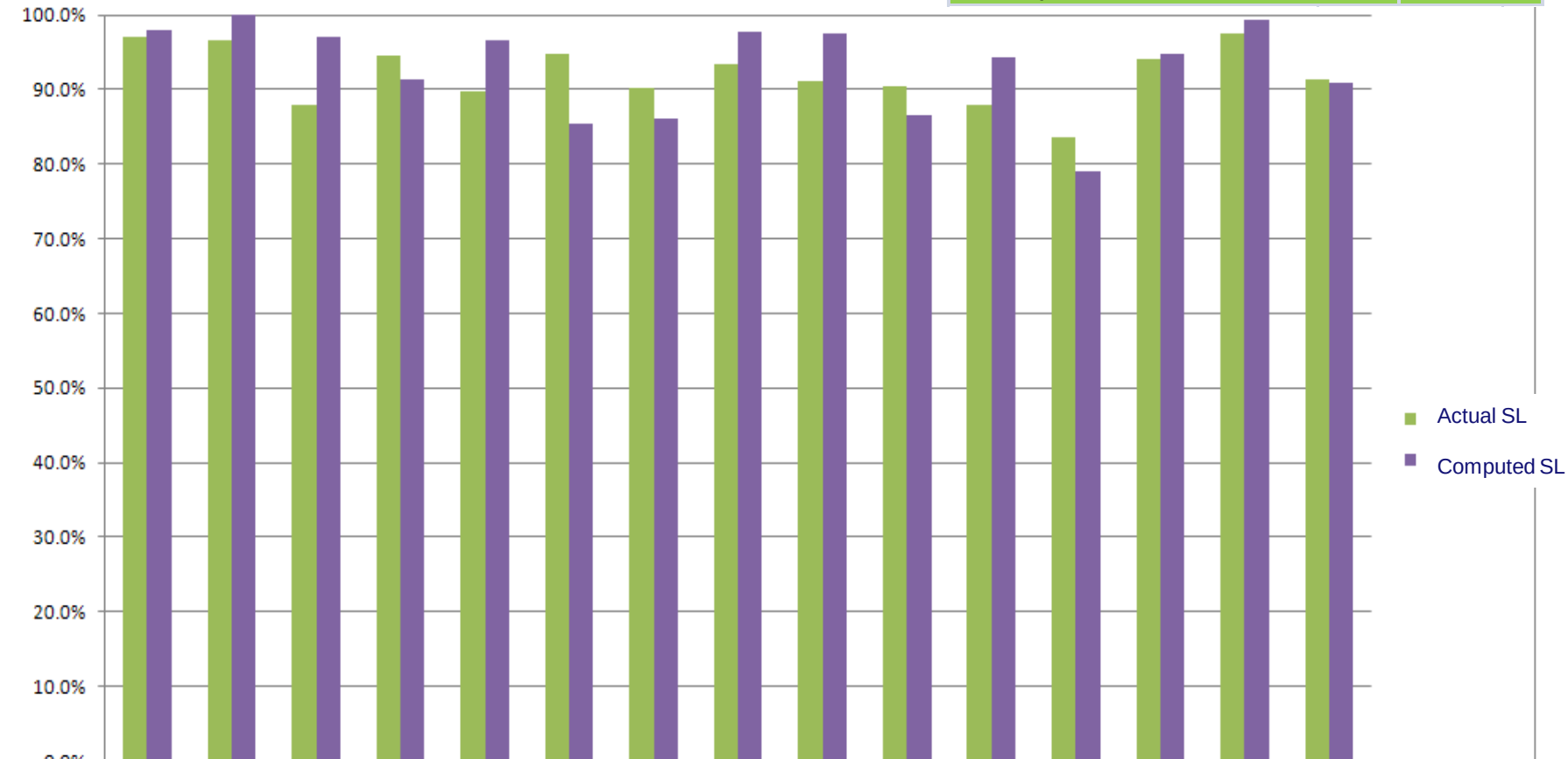
- **Given sku stocks across the network, BOM structure, and the item parameters**
  - **Lead time**
  - **Lot size**
  - **Customer lead time (item-customer combinations)**

  compute the customer service level achieved towards customers

- **Customer service level definitions**
  - **Fill rate**
    - **Long-run fraction of demand delivered within the agreed customer lead time**
  - **Ready rate**
    - **Probability no customers waiting longer than agreed customer lead time at the end of an arbitrary time bucket**
- **Compare computed service level and actual service level**
  - **At various levels of aggregation**

D2I3CV1C: Actual vs. computed SL

Actual service level	91.40%
Computed service level	90.80%



														Total
DRM	97.0%	96.5%	88.0%	94.5%	89.7%	94.7%	90.2%	93.3%	91.1%	90.5%	87.9%	83.6%	94.1%	97.5%	91.4%
ReadyRate	98.0%	100.0%	97.0%	91.3%	96.5%	85.4%	86.1%	97.8%	97.5%	86.6%	94.4%	79.1%	94.7%	99.4%	90.8%

Generic validation issues

- Transient versus stationary
  - High coefficient of variations of customer interorder times and customer order quantities cause higher service levels than predicted by stationary models
    - "Waiting time paradox" implies we are more likely to measure in sparse demand intervals
    - Transient fill rate analysis confirms this (cf. Thomas (2005), Chen et al. (2002))
- Allocation mechanism unknown
  - Sample average of physical stock is not completely explaining item fill rates
- Lead time definition by no means trivial
- Getting correct lead time data neither
- Quintessential to know service level definition and how it is measured before you can compare
  - Fill rate is not equal to ready rate!

Generic validation issues

- **Validation is considerable effort, even with today's ERP systems**
  - **In multi-echelon supply chains data are spread across multiple databases**
  - **Parameter setting and order release is a often manual effort that does not require a high level of data integrity, whereas validation studies do need this**
- **Education in probabilistic thinking is very weak**
  - **Planners expect 100% hit of service level**
  - **Hard to explain effect of transient behavior**

Design principles for ISC

- Inventory capital concentrates at User/Consumer Order Decoupling Points determined by SLA's
- High stocks in time for low-cost long lead time items
- Upstream efficiency focus hardly impacts the service offered to user/consumer
- Upstream efficiency focus hardly impacts capital investments, provided that short-lead time items are synchronized with long lead time items
  - Major part of lead time no materials and resources are committed
  - Left-to-right-planning as opposed to MRP's right-to-left-planning

Focus on downstream integration

- Long-term: make what you (think you) can sell
- Short-term: (try to) sell what you know you made
- Revenue management key enabler for reducing forecast error
- The last link is the weakest
  - Upstream investments in flexibility hardly impact consumer service
  - Shelf management by manufacturer has great potential for performance improvement
  - Service parts management by OEM allows for a multitude of flexibility options

SSC case studies







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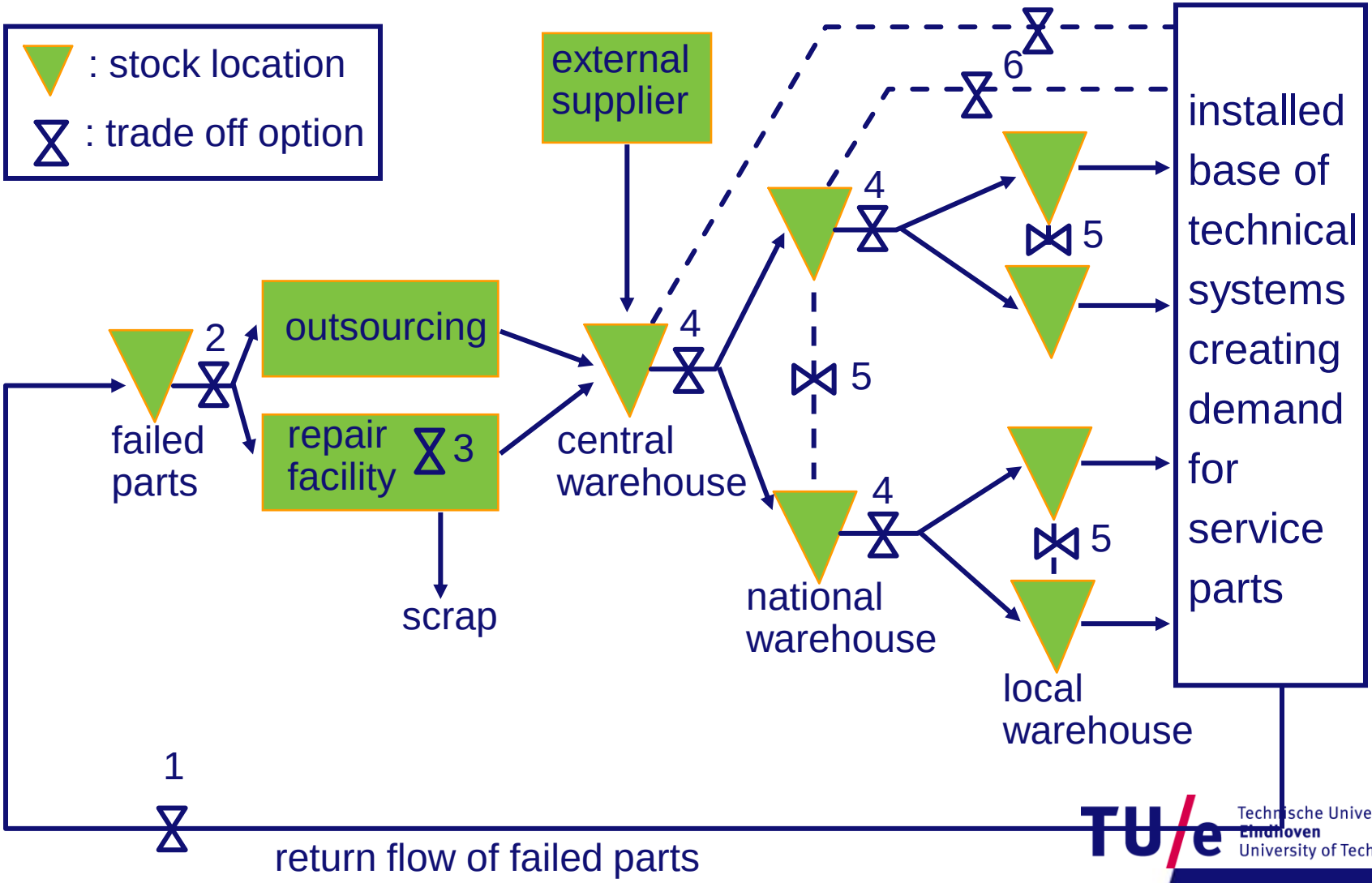
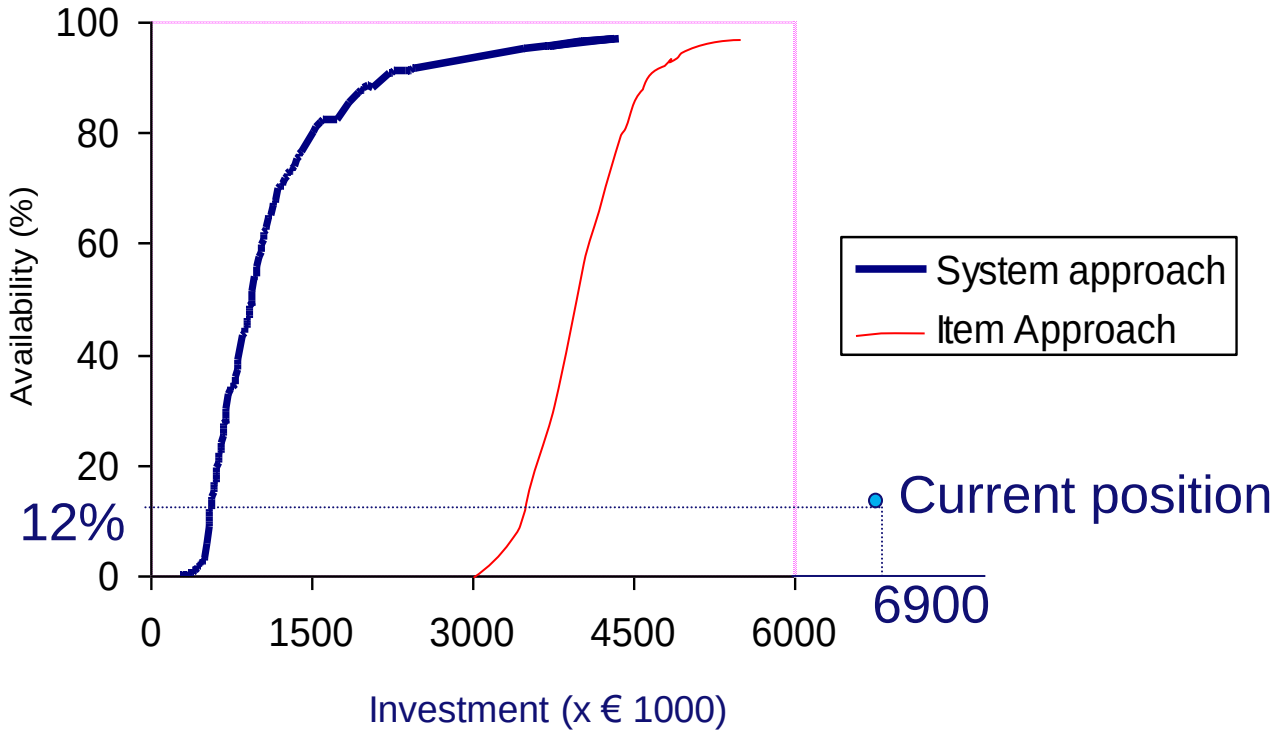
Flexibility options



SSC case: System approach versus item approach



Design principles for SSC

- **Requirements w.r.t. availability must be formulated at system-level.**
- **Avoid decomposition to requirements defined at lower levels and integrate decisions as much as possible**
- **Integrate decisions with respect to tools and parts deployment when possible**
- **Ensure that resources and parts are “pooled” as much as possible**
- **Use primarily the cheapest flexibility option**

Double whammy

- **In SSC increased network density yields more responsiveness at lower cost**
  - **Exploit co-location of manufacturers**

The warm bath of the decentralized supply chain

- Decentralized supply chains rely on Service Level Agreements (SLA's) defined in contracts
  - orders should be received within two weeks, say, and with 95%, say, reliability
- Consequence of SLA's is proliferation of inventory capital across the supply chain
- Downstream partner assumes that SLA's always work
- It is just a matter of transactions
  - orders
  - shipments

The cold shower of decentralized supply chains

- Relevant lead time is not the lead time of 1st tier supplier, but the cumulative lead time of all upstream tiers
- When demand surges, supply chain empties itself, yet surge is communicated after substantial delay due to link by link communication
  - lost sales in the market place
- When demand plummets, upstream stocks build up
  - liabilities issues
  - obsolescence

Conclusions

- State-of-the-art mathematical modeling captures real-life relationship between investments and operational performance
- State-of-the-art mathematical modeling allows for supply chain optimization during the product life cycle
- Huge potential for investment reduction and service improvement
- Efficient frontier solutions differ from common sense solutions
  - Need for education and training

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