17th International Conference on Concurrent Enterprising

"Innovating products and services for collaborative networks"

Developing a production engineering based theory of production

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Outline

1 Key challenges for production technology in high-wage countries

2 A production engineering based theory of production

3 The Value Added Model

4 The Cybernetics Model

5 Conclusion

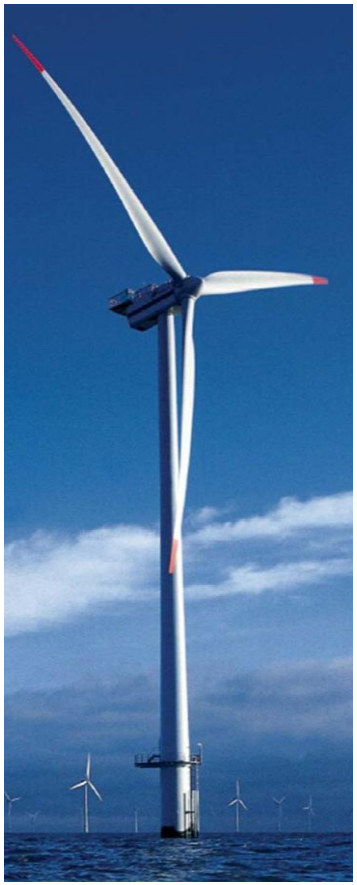
Outline

Fast, market-ready innovations are the key to success for high-wage countries

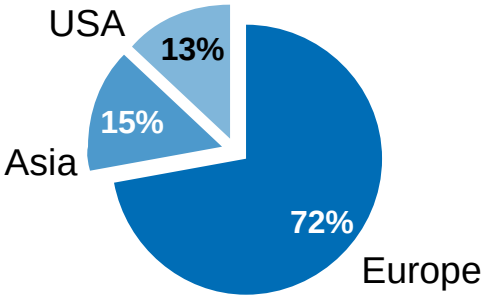
Factors of success for high-wage countries like Germany

1. Offering a wide range of product variants at competitive prices by taking advantage of the ***economies of scale***.
2. Reducing the risk of imitations through ***highly innovative products***.
3. Staying one step ahead of the competitors by ***shortening the time-to-market***.
4. Enhancing ***ressource efficiency*** in the product life cycle

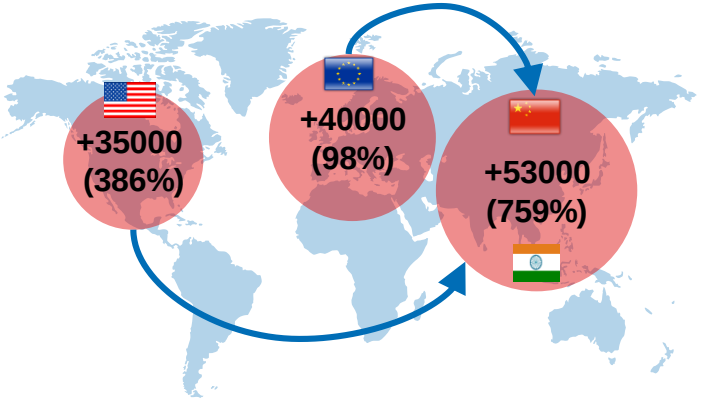
Example wind power



Market share of manufacturing wind power plants



Newly installed wind energy capacity (in MW) from 2006 to 2010



Quelle: WZL, BTM Consult ApS - 26. März 2007, World Wind Energy report 2008 -2010

The polylemma of production is resolved by simultaneously addressing the poles of the field of tension

Planning economy

Value orientation

- Decentralized near-process decision making
- Standardised methods and procedures
- Elimination of “muda”

Planning orientation

- Centralized Knowledge Management
- Integration of virtual models and real world applications
- Intense use of resources

Production economy

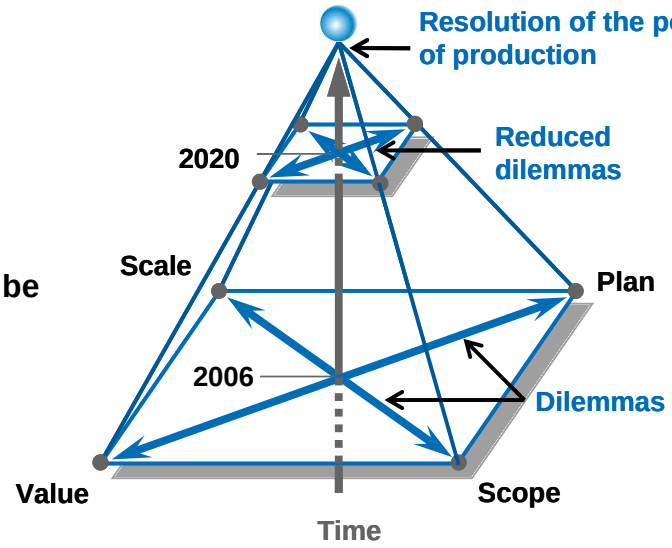
Economies of scale

- Continuous throughput
- Synchronised processes
- standardized products and processes
- High frequency production cycle

Economies of scope

- One-Piece-Flow
- flexibility and versatility
- dynamic and complex production creation chains

How can a good synchronisation of objectives for all activities with simultaneously high sytem dynamic be achieved?

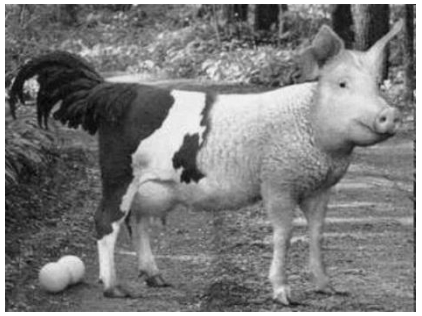


How can products be realised with minimum production costs, which are matching perfectly with customer demands?

The solution hypothesis for companies in high-wage countries is higher integrativity in production technology

Definition of Integrativity

- Holistic approach to simultaneously address economic, ecologic and social challenges for production technology in high-wage countries
- Interdisciplinary inter-divisional cooperation in research and industry
- Expansion of the solution space by combination of established technological and managerial approaches



Prerequisites for integrative production technology:

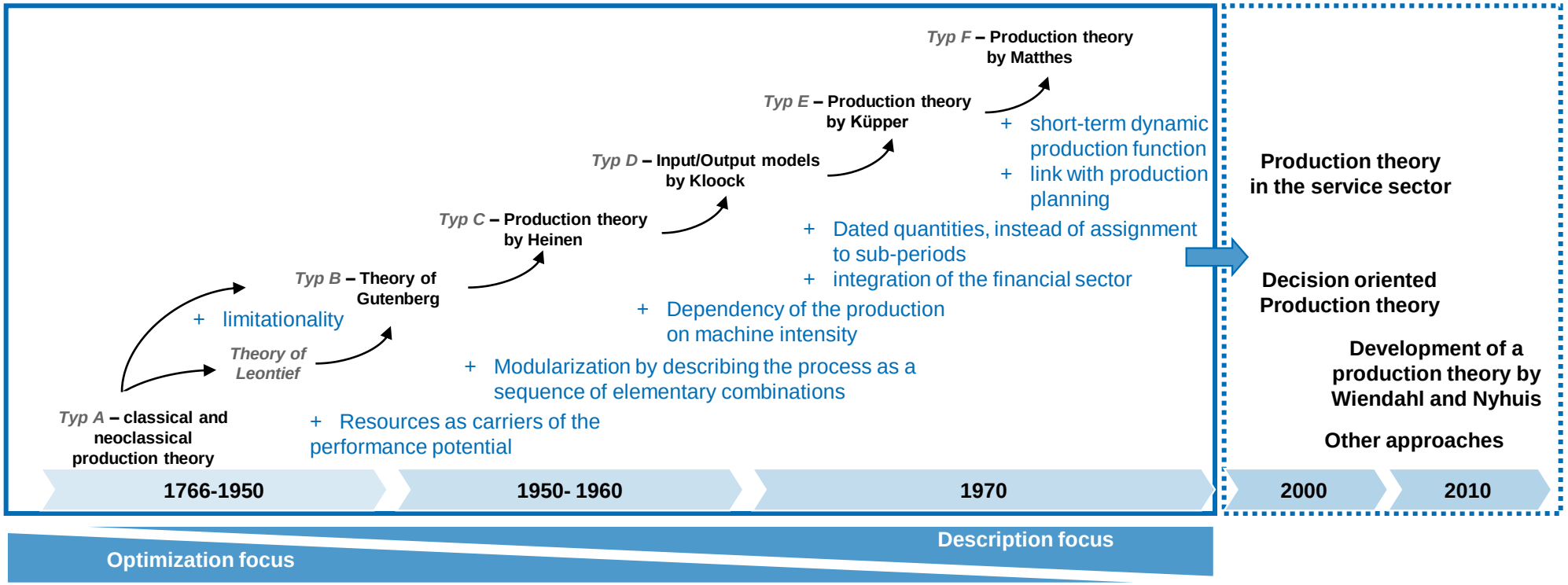
- Sound understanding of a production system's mathematical and physical fundamentals
- Regulatory framework for interdisciplinary collaboration and knowledge management

Central hypothesis:

Integrativity is the key to generate social added value by enabling competitive production technology in high-wage countries.

Outline

Production theories deliver a theoretical approach to describe the cause-effect relationships of production systems



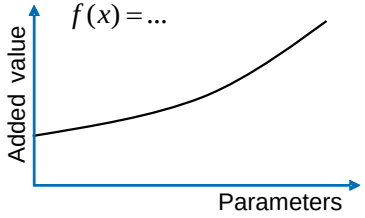
Evaluation of existing production theories

- lack of engineering basics to describe interrelations of technologies and production.
- insufficient description of interdisciplinary interdependencies in production systems.

Development of a production engineering based theory of production

Theory of Production (Virtual World)

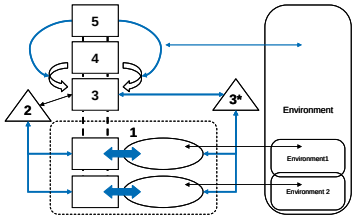
Value Added Model



Emergentism
Find phenomena and structures

Reductionism
Find particles and interaction laws

Cybernetics Model



Comprehension

Design

Materials (m)

Means of Production (n)

Trans-formation

$P = f(m,n)$

$F = f(m,n)$

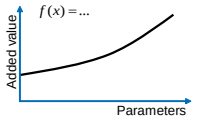
Products (P)

Function (F)

Production System (Real World)

Outline

Interdisciplinary interactions of production technology need to be described mathematically and physically



bottleneck

Turning → FIFO → Case Hardening → FIFO → Grinding

- The tool costs (K_{WZ}) depend on the coat thickness b (about 5mm) and the price K of the grinding wheel (about € 5.000) as well as on the dressing infeed.

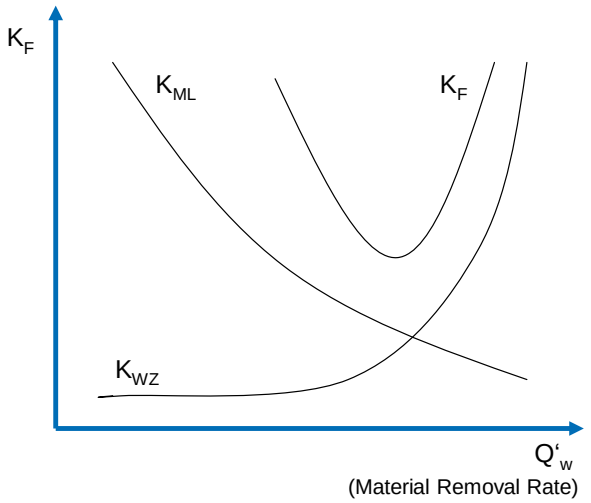
$$K_{WZ} = \frac{a_{ed}}{n \cdot b} \cdot K$$

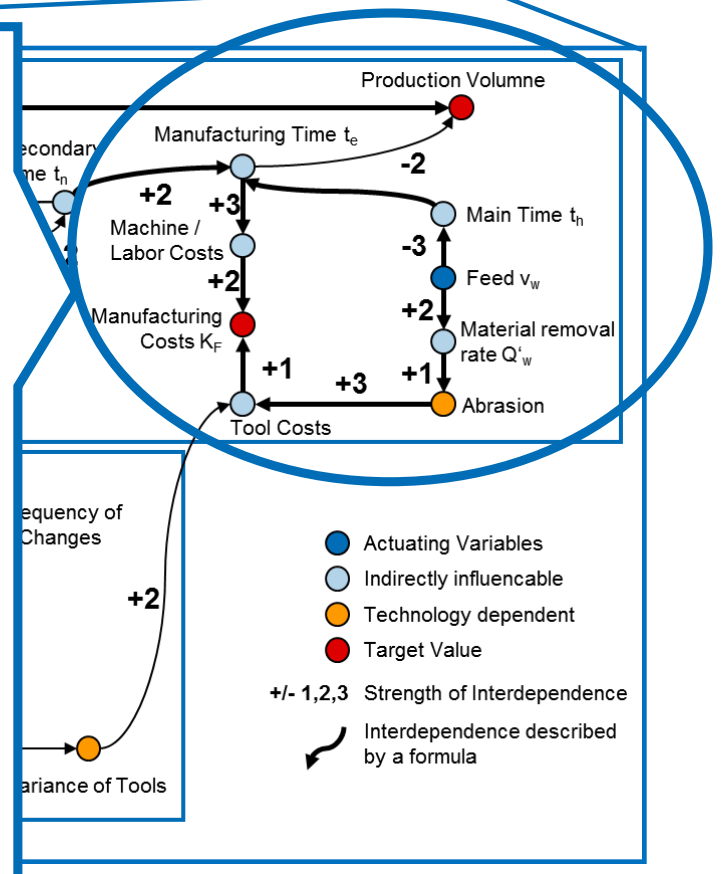
- Costs have two components
  - Machine and Labor Costs K_{ML}
  - Tool Costs K_{WZ}

$$K_F = K_{ML} + K_{WZ}$$

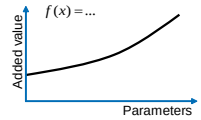
- Machine and Labor Costs

$$K_{ML} = \left(K_{MH} + K_{LH}\right) \cdot t_e\left(Q'_w\right)$$



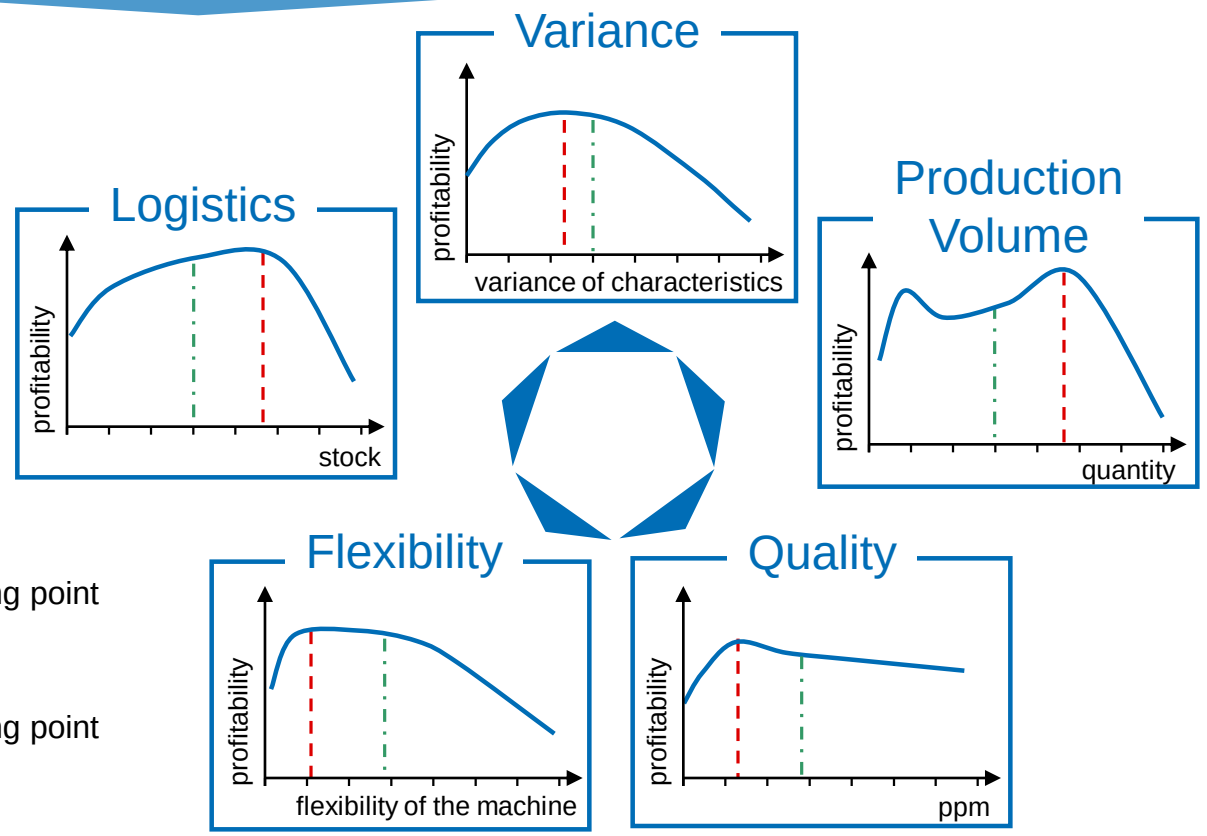


The goal is to identify actuating variables and target values as well as their cross-dependencies



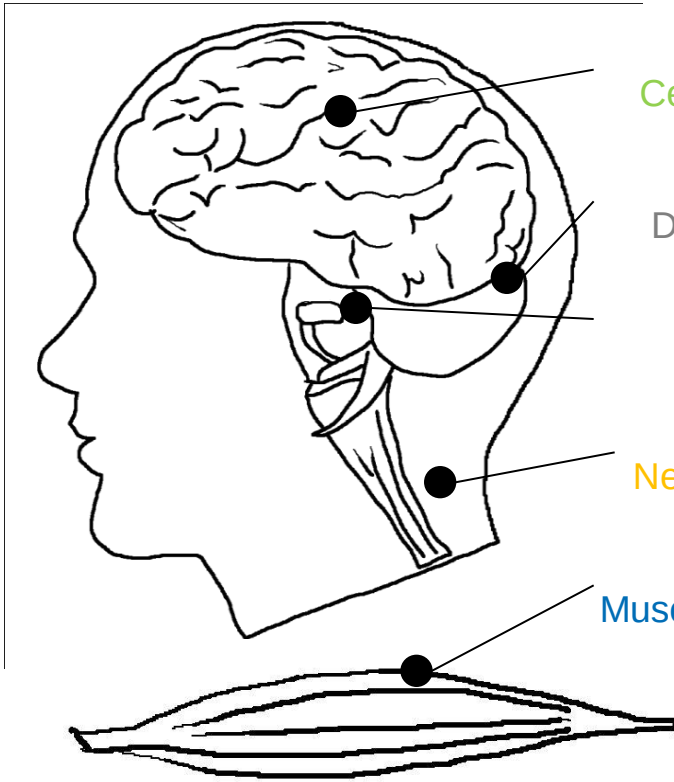
Formula-based description of production technological interdependencies within a production system

- To avoid intradisciplinary local optimization, the **interactions between the dimensions of evaluation** need to be examined
- The **interdisciplinary approach** allows the derivation of the overall **optimal operating point**



Outline

The human being is the perfect archetype to design a complexity oriented structure for a cybernetic management system



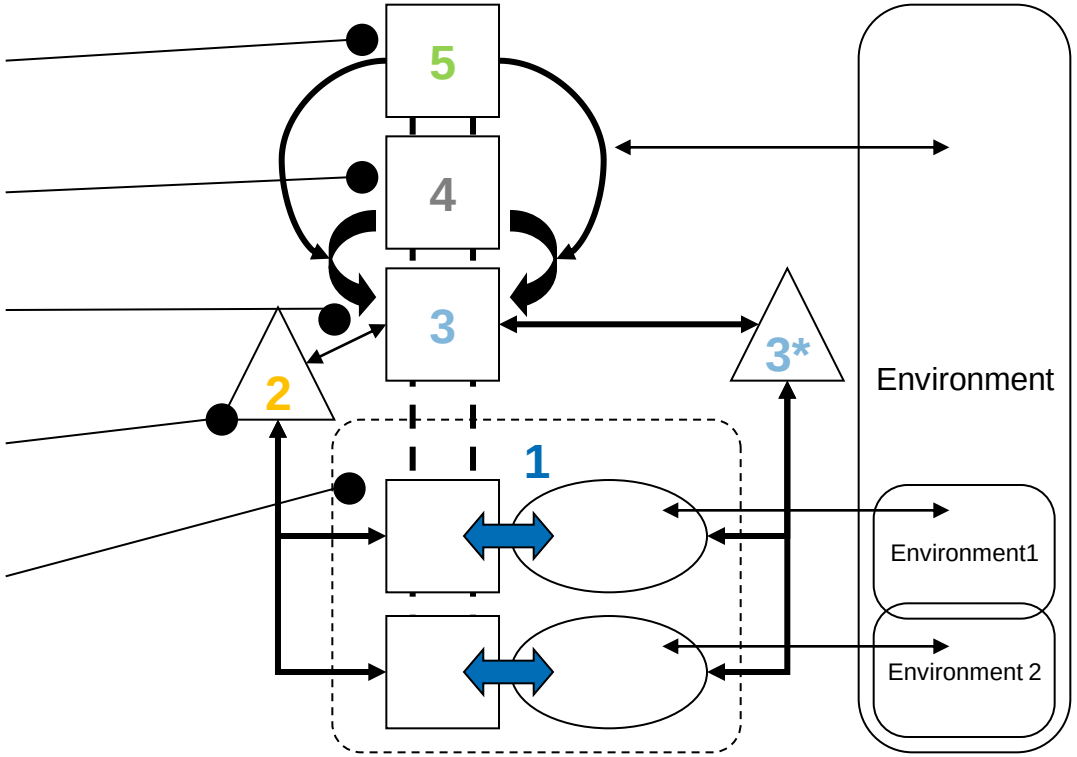
System 5
Cerebral cortex

System 4
Diencephalon

System 3
Brainstem

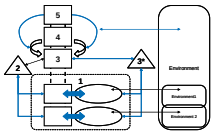
System 2
Nervous system

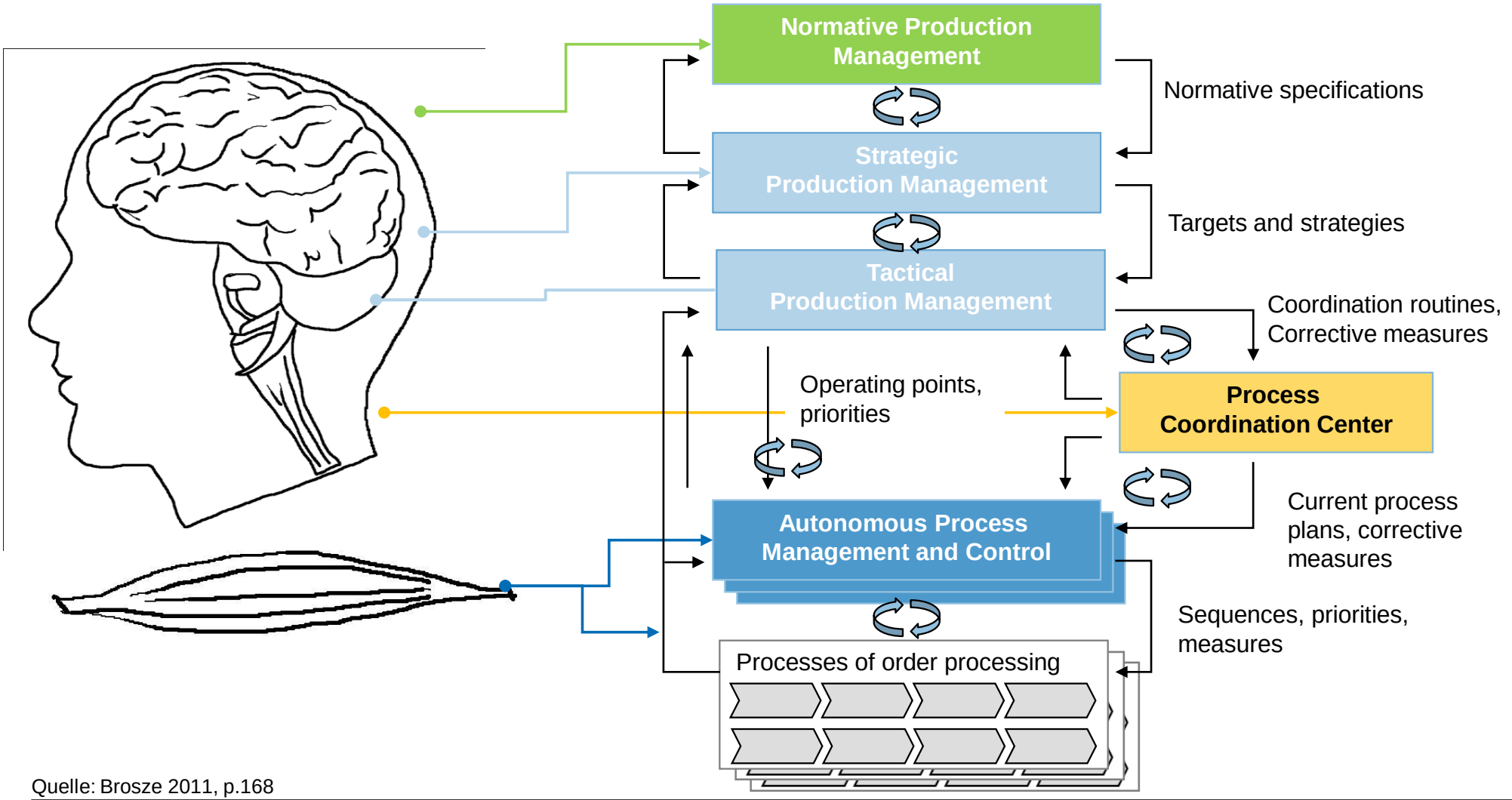
System 1
Muscles and organs



Quelle: BEER 1979, pg. 319; MALIK 2006, pg. 84; GOMEZ 1978, pg. 24;ESPEJO U. HARNDEN 1989, pg. 99

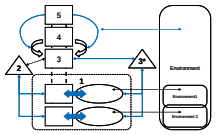
The Cybernetic Production Management System fosters maximum autonomy, continuous learning and structural evolution





Quelle: Brosze 2011, p.168

The multilevel structure enables a self-preservating system based on autonomous elements



- Definition of Identity

- Environment and Change Monitoring
- Development of Production Strategy
- Design of Production System

- Process Configuration
- Process Guidance and Control (hierarchical)
- Process Coordination (hierarchical)
- Process Monitoring

- Process Synchronization (non-hierarchical)
- Process Stabilization (cross-process)

- Process Control
- Process Optimization
- Process Monitoring
- Process Stabilization
- Project Monitoring

Normative Production Management

Strategic Production Management

Tactical Production Management

Process Coordination Center

Autonomous Process Management and Control

Processes of order processing

Normative specifications

Targets and strategies

Coordination routines, Corrective measures

Operating points, priorities

Current process plans, corrective measures

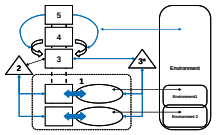
Sequences, priorities, measures

Granularity and accuracy of reference values

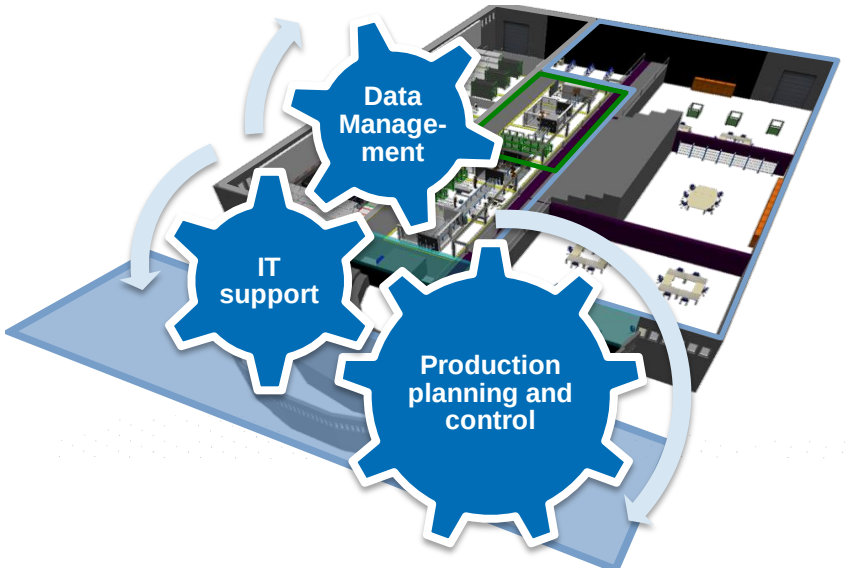
Response-time behavior

Dynamic reference value corridors

To develop cybernetic control mechanism, new ways of experimental research will be performed in the Enterprise-Integration-Center



Enterprise-Integration-Center (EICe)

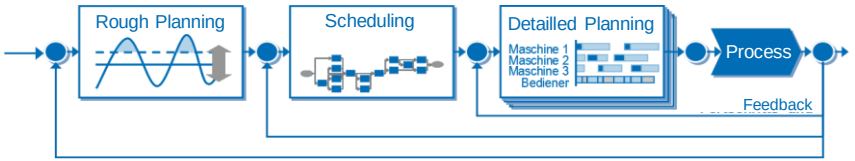


Interoperable IT support

- Standardized IT structures and systems to reach versatility (ERP-as-a-Service, Best-of-Breed etc.)
- Barrier-free cross-company communication in real-time using transmission standards

Cybernetic Production Planning and Control

- Mastering dynamics with almost real-time processing of reported informations



- Decentral and robust control systems to separate automated and manual actions and reactions

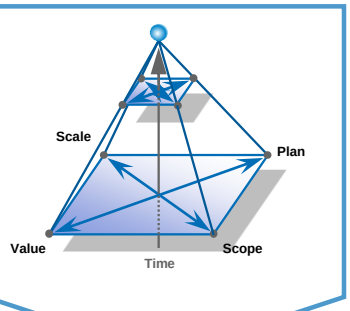
Data management for High Resolution

- High Resolution identification of materials, parts and process status

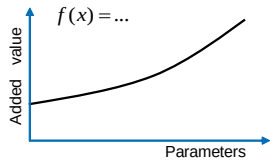
- Mastering dynamics with the update of relevant data (Refurbishment times, prices, etc.)

Outline

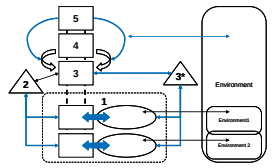
A production engineering based theory of production is the key for success in high-wage countries



1. *Integrative production technology generates social value in high-wage countries.*



2. *The Value Added model delivers a formula-based description of production technological interdependencies within production systems*



3. *The Viable System Model allows to integrate autonomous but interdependent subsystems in a production system, which is capable to self-preserve under dynamic conditions.*

Thank you for your attention!

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