

Informatization in Production Planning and Control

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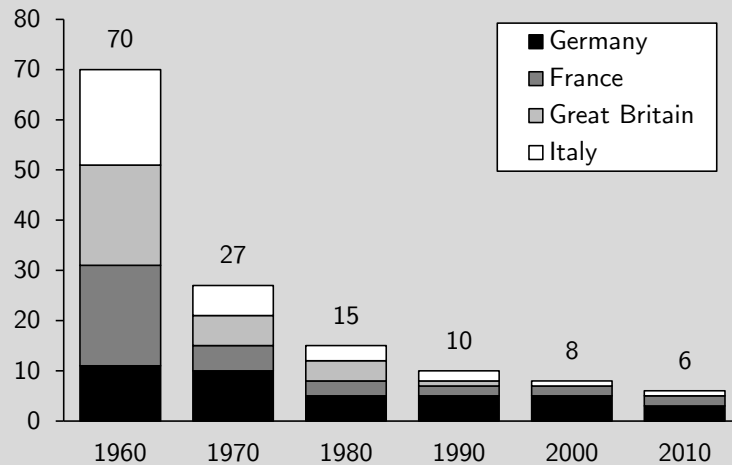
Structure

1. Ongoing Challenge - Individualization
2. Production Planning and Control
3. New Prospects - Informatization
4. Evaluation Study
5. Open Issues

1. Ongoing Challenge - Individualization

Industrial Trends in Automotive Industry

- Increasing competitive pressure and globalization
- Individualization of products



Brand concentration in the European Automotive Industry

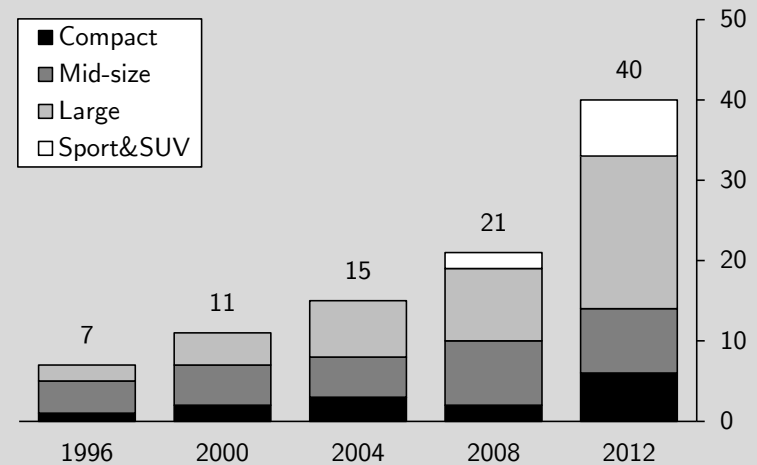
Data from a study of KPMG (2010)

Germany 2010: BMW, Mercedes Benz, VW (not including brands of US manufacturers)

France 2010: PSA, Renault(-Nissan)

Great Britain 2010: no manufacturer (Rover is since 2005 part of Tata)

Italy 2010: Fiat



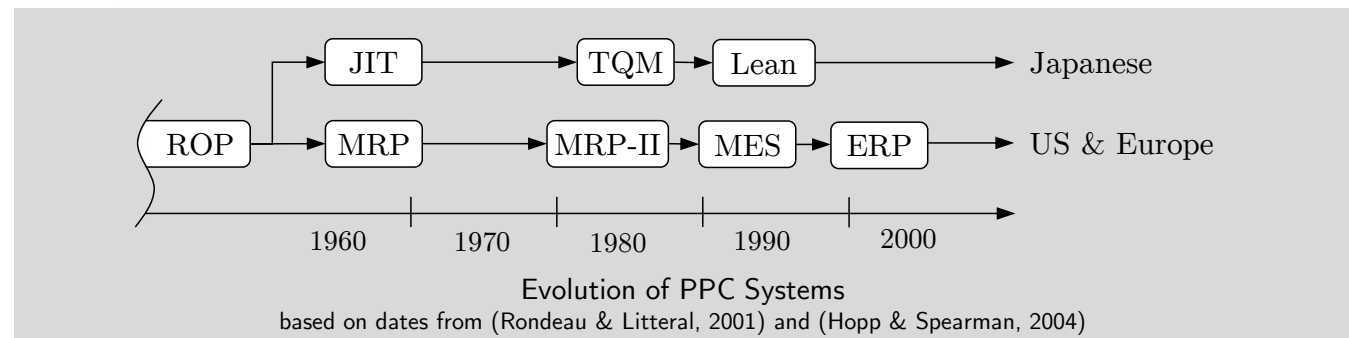
Development of the Model Range of Audi

Data of 1996 – 2008 from Krog & Statkevich (2008), 2012 from the webpage of Audi (2012)

Compact: A1, A2, A3; Mid-size: A4, TT; Large: A5, A6, A7, A8; Sport&SUV: R, Q

2. Production Planning and Control Methods

Classification	Push - MRP	Pull - JIT
Order Release ¹	Orders/Forecasts	Removing an Item
Information Flow ²	Centralized	Decentralized
WIP Level ³	No limitation	Explicit limit of WIP
Challenges	<ul style="list-style-type: none"> ▪ Lead times ▪ Lot sizes ▪ Safety stock ▪ Incentive for improvement ▪ Required high data consistency ▪ System Nervousness 	<p><i>JIT is for example not appropriate in environments where, variability is high, and demand is extremely nonstationary.</i> (Silver, et al., 1998)</p>



¹ (Karmarkar, 1988)

² (Benton & Shin, 1998)

³ (Hopp & Spearman, 2008)

2. To Push or to Pull, that is the Question

General

- Krajewski et al. (1987) performed one of the earliest and largest comparison studies of MRP and JIT and concluded that it is not the Kanban system which makes the system attractive. It is mainly the **flow environment** established through the JIT philosophy **which makes the difference**.
- Spearman & Zazanis (1992) found out that it is not the pull principle itself, it is the **limit in the level and variability of WIP** inventory which leads to superior performance.

Flexibility

- Plenert (1999) compared MRP and kanban with respect in flexibility and concluded that **when flexibility is needed MRP is the unique answer** as it can be introduced to a huge range of environments. **Only MRP can deal with product variability and customization as well as flexibility in the production process.**
- Krishnamurthy et al. (2000; 2004) performed several simulation studies with **multiple products and changing product mixes** which showed that **push yields to better performance** in terms of service level and average inventory.

3. New Prospects - Informatization

The need to **reduce the time to market** with more **customized products** led to the excessive use of IT in manufacturing:

- **Computer Integrated Manufacturing (CIM)**
- **Digital Factory**
- **Internet of things (IoT)** is the interconnection of uniquely identifiable devices within the existing Internet infrastructure. **Radiofrequency identification (RFID)** is the enabling technology that will link the real world with the digital world (Atzori, et al., 2010).
- **Cyber physical systems (CPS)** are through networks interacting elements which have physical input and output. The key enabler for CPS is the ability to interact with the physical world and other embedded controllers through communication (Lee, 2008).
- **Industry 4.0** will involve the technical integrations of **cyber physical systems** into manufacturing and logistics and the use of the **Internet of Things and Services** in industrial processes. This will have implications for value creation, business models, downstream service and work organization (Plattform Industrie 4.0, 2013).

3. Data Quality

Data quality in industrial manufacturing is often far away from high quality data. Written documentation is often used as feedback of inventory data from the shop floor:

- 57% of the small and medium-sized enterprises and
- 39% of the large-scale enterprise located in Germany (Schuh & Stich, 2013).

In Industry 4.0 the operative PPC is often seen in a **real-time machine learning optimization loop** using realistic in-detail models of the production system and the sensors and actuators of the CPS. The **real time data** and the tracking of all activities and objects in the real world can be used in PPC.

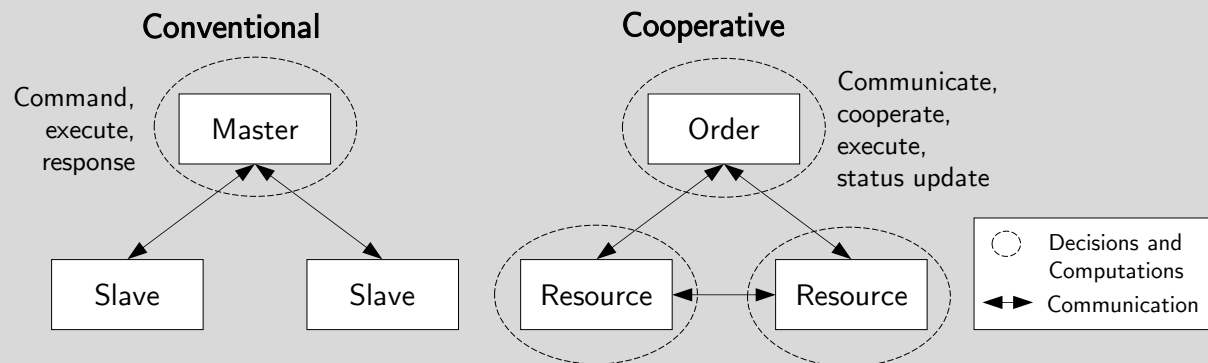
Through the availability of data and the real-time interconnectivity of CPS the **complexity will increase dramatically** through Industry 4.0 (Bauernhansl, 2014).

3. Complexity and Decentralization

In cybernetics the complexity of a system is measured by the **variety**, which is the total number of **possible states** the system can have. The **law of requisite variety** states that only variety in the control can force down the variety of a system – *only variety can destroy variety* (Ashby, 1956).

This idea is also embraced in the visions of Industry 4.0 in which **decentralized decision making** is seen as the way to deal with this requested complexity (Bauernhansl, 2014).

Agent-based computation is the paradigm that can handle the new degree of availability of information and has the ability to process it quickly (Monostori, et al., 2006).



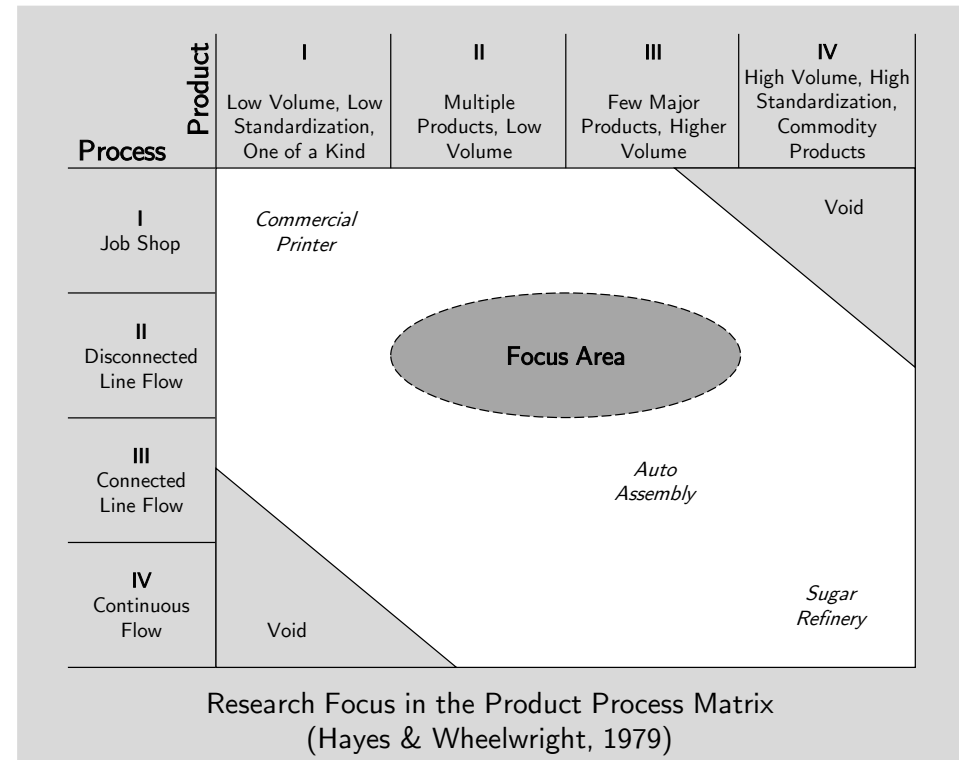
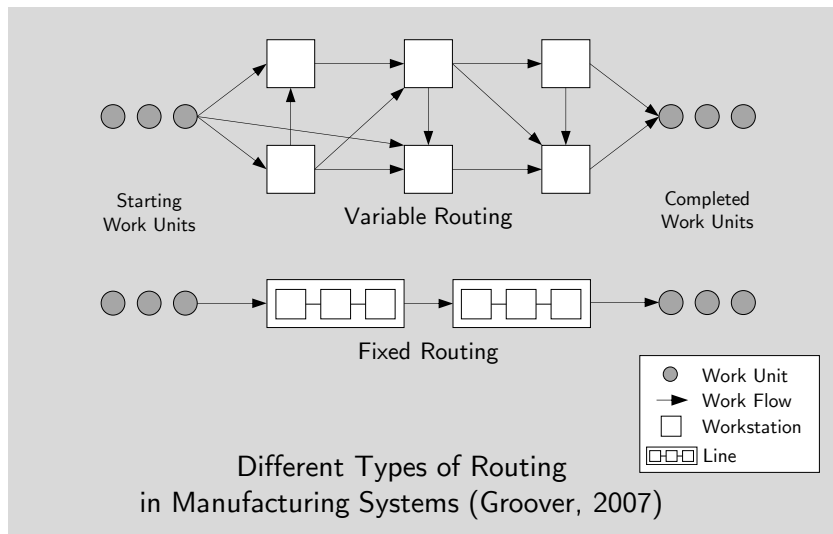
Conventional and Cooperative Approach to Decision-Making (Marik & McFarlane 2005)

4. Research Focus: Disconnected Line Flow

were the main PPC Challenge is to **specify and coordinate** with the other lines the **quantity** and **timing** of the production jobs of the **individual types** to **fulfill** the needs of the downstream customers while **keeping** the overall **WIP low**.

Needed flexibilities in this environment according to Slack (1987):

- **Product flexibility**
- **Mix flexibility**
- **Volume flexibility**



4. Research Aims

- Information Quality

What Information Quality is needed? (time, error-range)

- Level of Detail

What is the appropriate Level of Detail of the PPC Model?

- Decision Hierarchy

How much decentralized/centralized elements in the Decision Making are needed?

Challenges

- Trend to Higher Individualization of Products (Increasing Product Variety)
- Volatile Markets (Need of More Flexible, Adaptable Structures)

Prospects

- Better Quality and Availability of Data (Informatization, Internet of Things)
- Autonomic Acting Cyber Physical Systems (Decentralization of Decision Making)

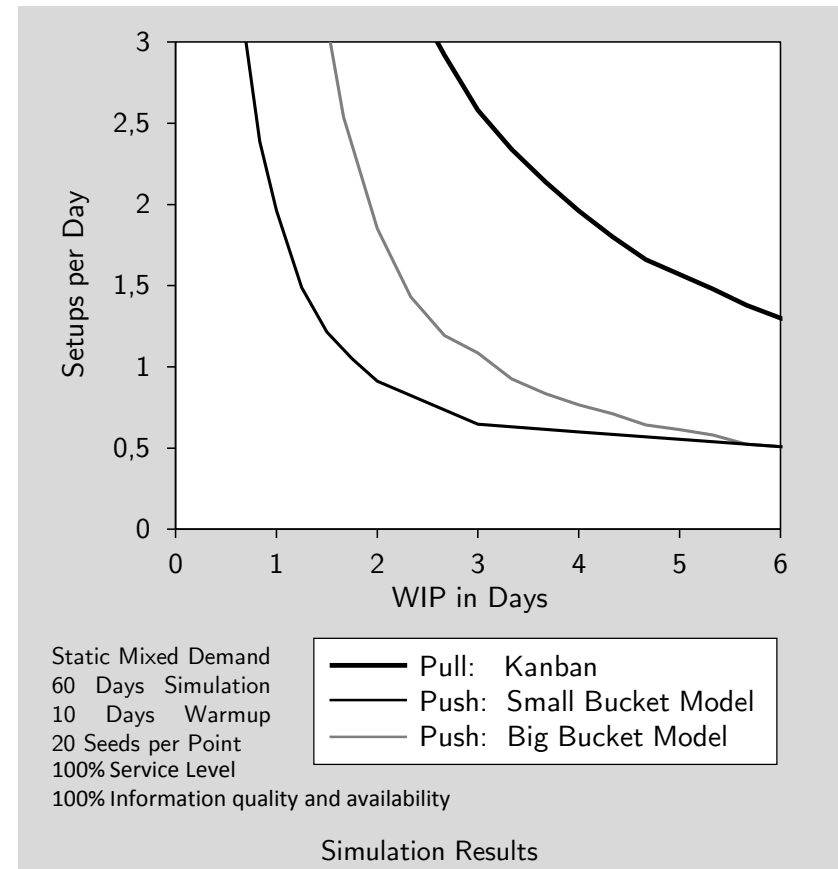
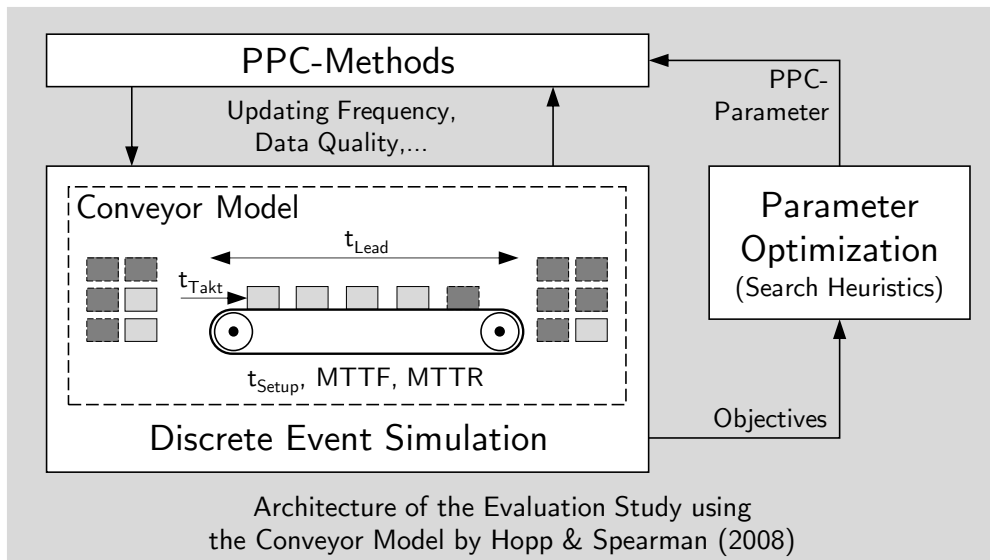
Aim: Evaluation of PPC Concepts using Simulation

Aim of the Thesis

4. Simulation based Evaluation Study

Simulation based performance analysis of various PPC-Methods:

- **Push-based**
 - Big bucket models
 - Small bucket models
- **Pull-based**
 - Kanban



4. Evaluation of Information Quality and Product Flexibility

Information

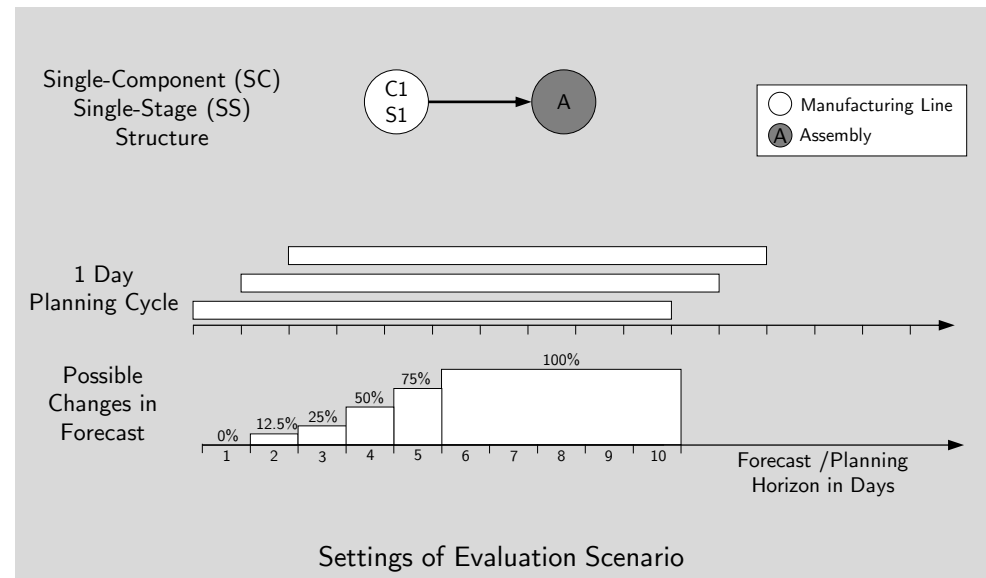
- Error Erlang distributed with σ of 10%, 25% of the actual value
- Rolling wave planning with horizon of 10 Days and cycle of 1 Day

Supply

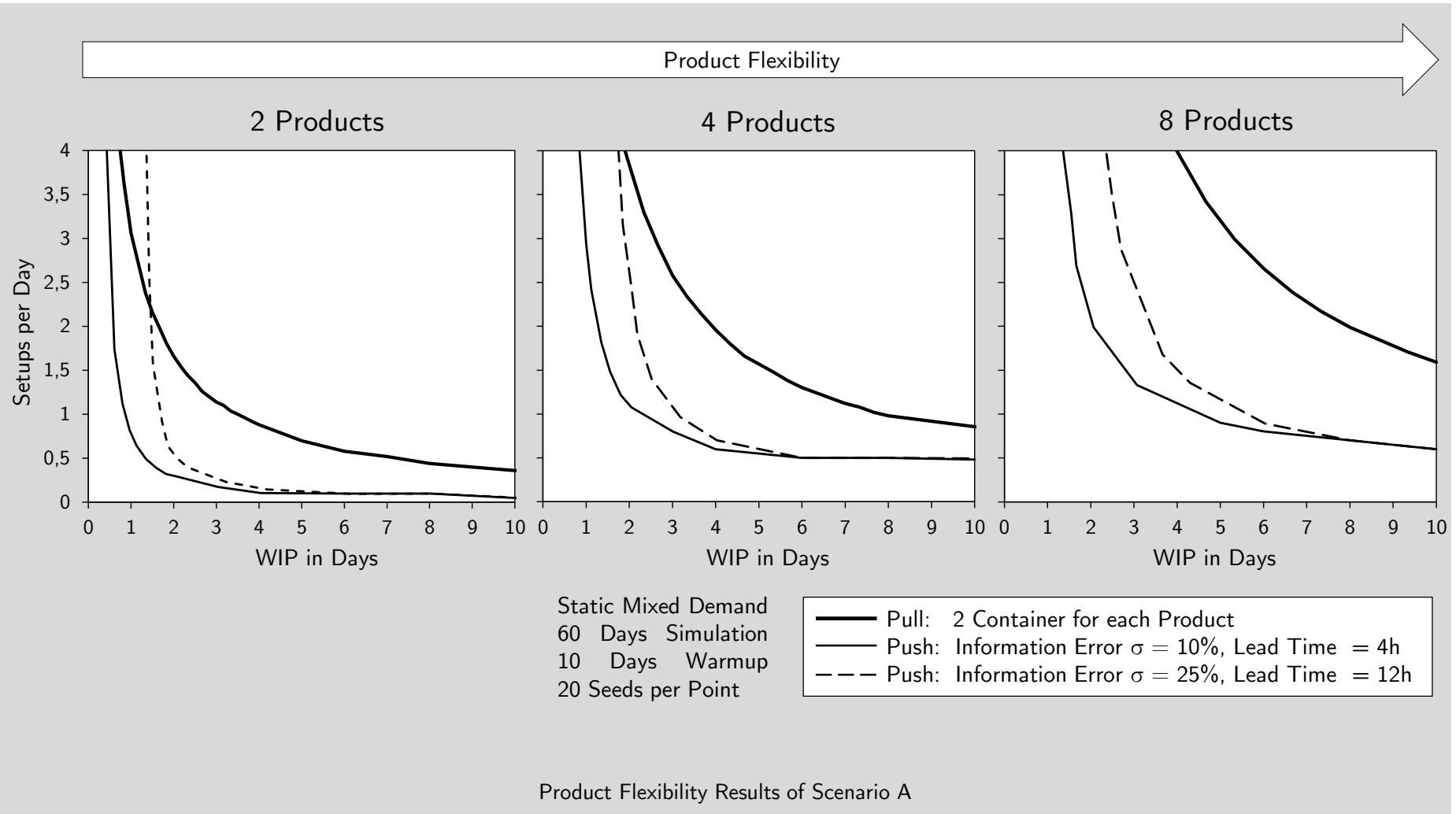
- Single-Component
- Single-Stage
- Zero Variability

Demand

- 2, 4, 8 Products
- Static Mixed
- Changes in Forecast



4. First Results

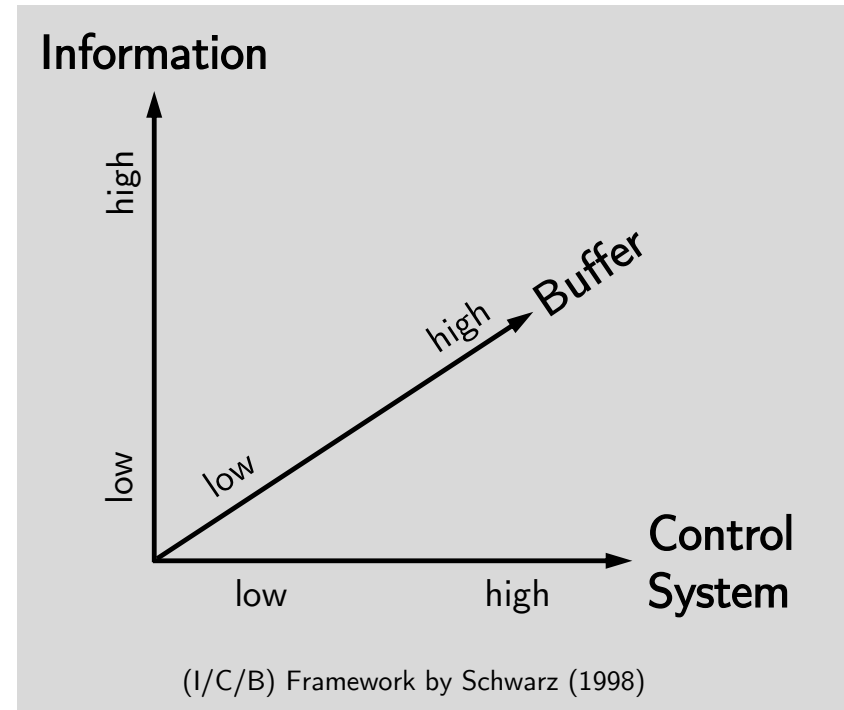


4. Decision Framework

based on Inventory, Control System, Buffer Framework by Schwarz (1998)

An operation should select its management system based on the **total costs** of the

- required **Information**
- **Control System**
- needed **Buffer** (Inventory, Capacity)



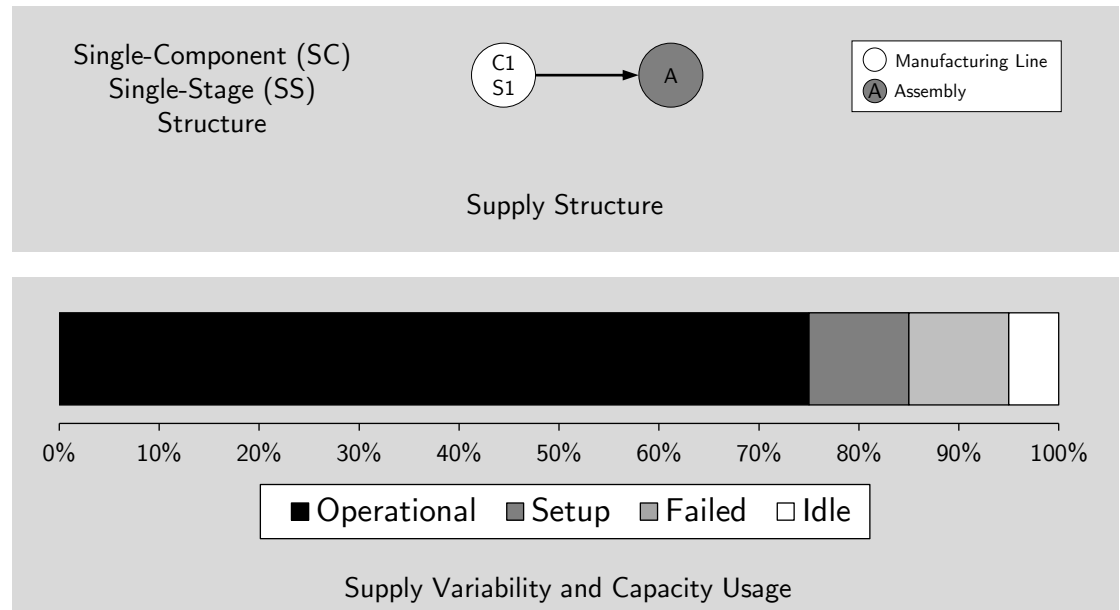
Extension

& the requisite **Flexibility** of the control system
(determined by the customer demand)

5. Open Issue: Supply Variability

Extend Evaluation Model with the Supply Variability

- Setup Times
- Breakdowns
- Quality Losses (Yield)

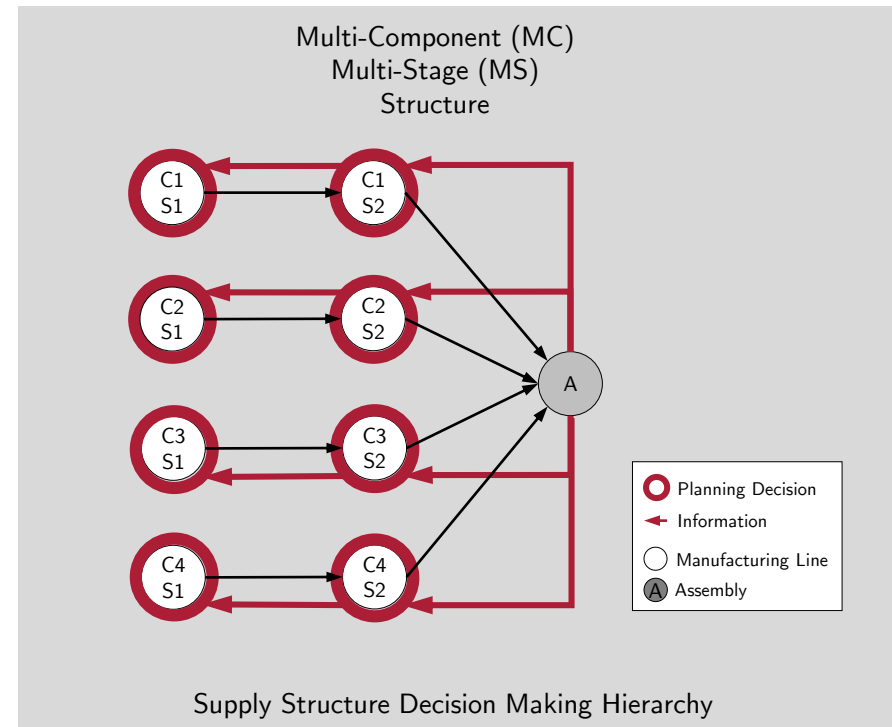
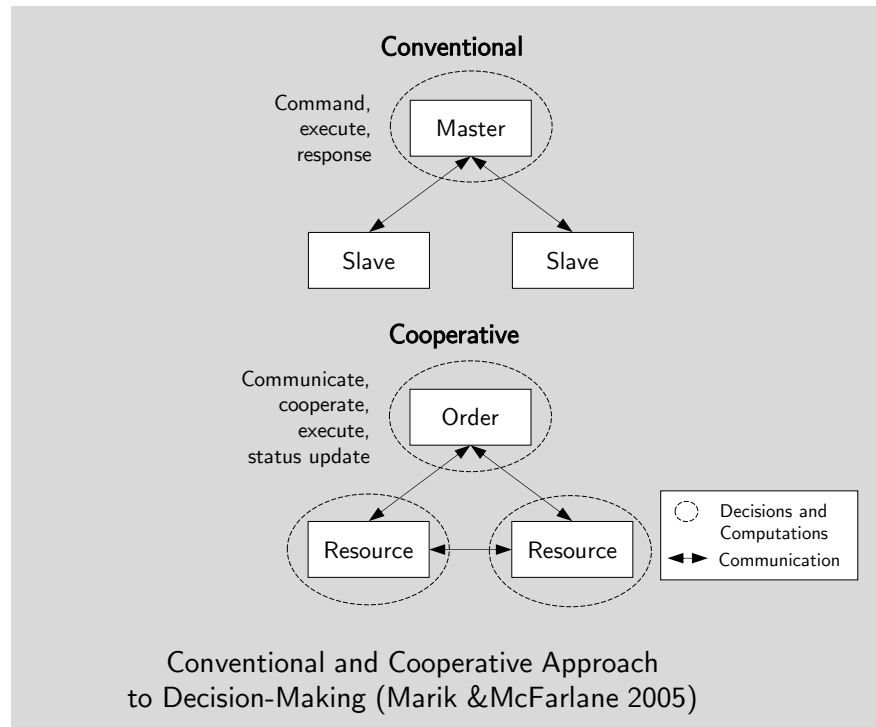


5. Open Issue: Decision Making Hierarchy

Extend Evaluation Model (Scenario A) to a Multi-Component, Multi-Stage Structure

Analyze the various Decision Making Hierarchies:

What is, based on the Supply Structure, the optimal Flow of Information?

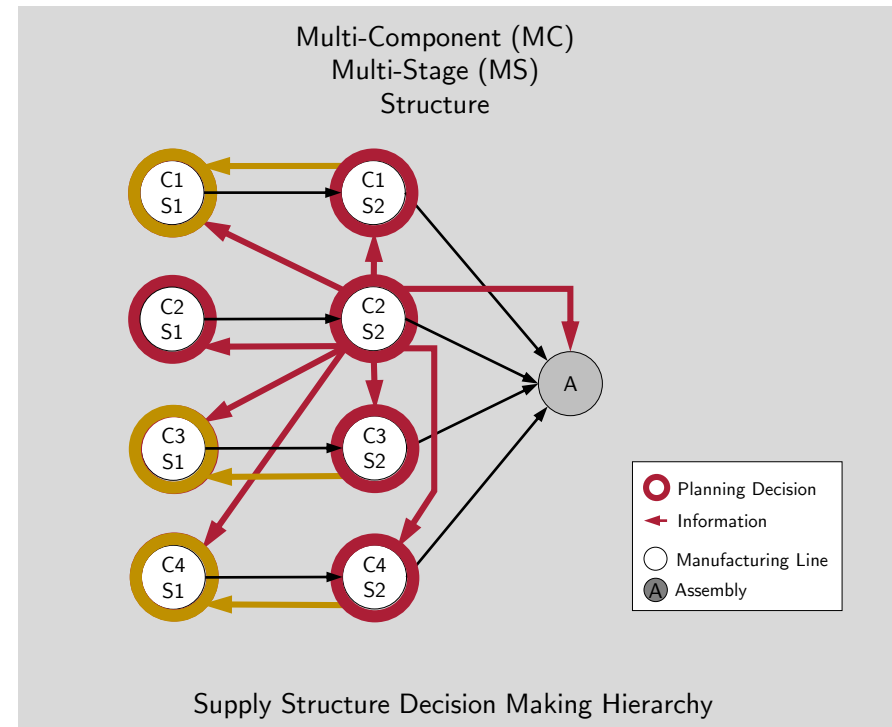
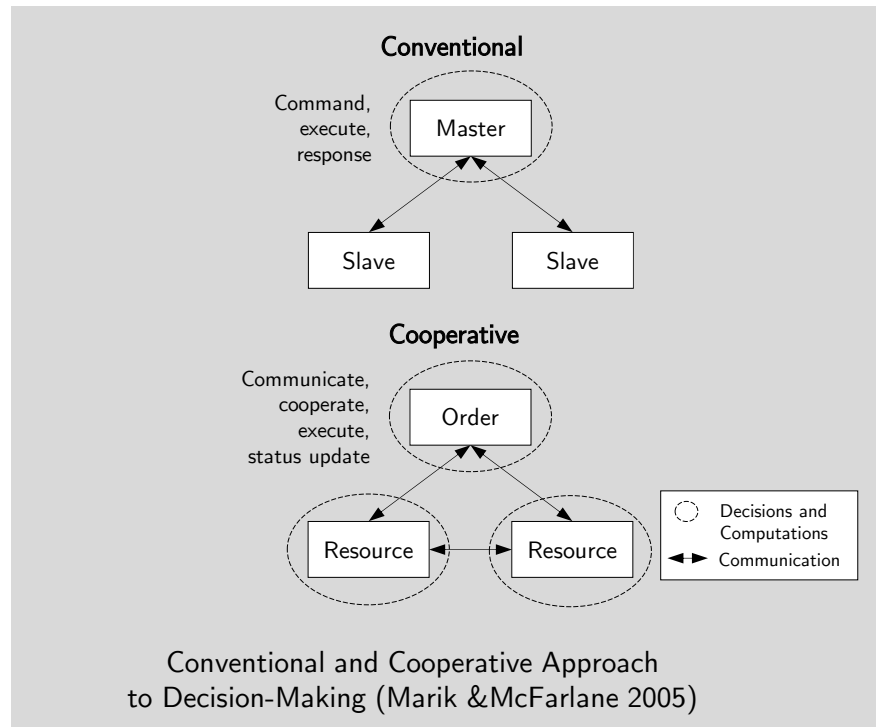


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Herzlichen Dank für ihre
Aufmerksamkeit