Reinforcing lean production through agility aspects

Alexander Pointner

Agenda

- Introduction and Motivation
- Lean and agile production
- Research gap and research questions
- First insights

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Volatility and uncertainty in industry

- More uncertainty and volatility in industry since financial crisis
  - Volatile industrial environment (i.e. raw material, energy)
  - Uncertain new technologies (i.e. digitization, e-mobility)
  - Unclear global correlations (i.e. China)

"I believe the auto industry will change more in the next five to 10 years than it has in the last 50."
Mary Barra (CEO, General Motors)

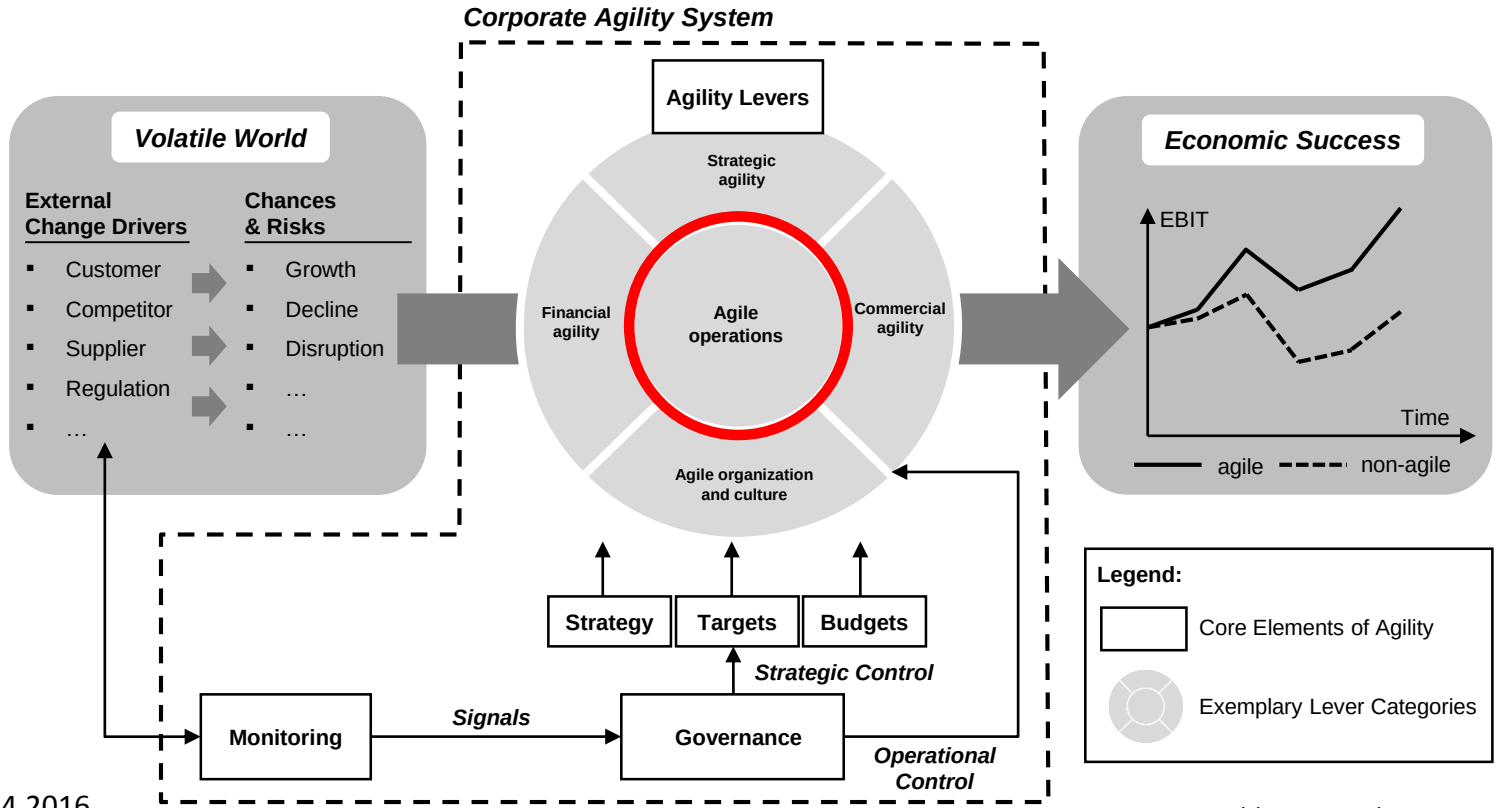
Source: ifo-Institut 2016; World Bank 2015; McKinsey Global Institute; Dobbs 2015

Answer: Agility in industry

- Research focus at the institute since two years
- Hollistic approach for agility necessary

- Definition of agility
  - *"Agility of a company is the capability to **prepare proactively** for uncertainties and to **react quickly** on changes to **optimize the economic situation** (e.g., EBIT, market share, ROI) of a company by leveraging the value chain."* [Schurig et al. 2014]

Agility in industry



Source: Heldmann et al. 2015

Feedback from industry 1/2

- Agility is necessary and has to be implemented to deal with volatile and uncertain environments
- Agility as new competetive advantage

“Die subjektiv gefühlte Unsicherheit nimmt definitiv zu und ich denke das geht derzeit jedem CEO in der Automobilbranche so.”

„Deswegen ist das Thema Agilität in der Zukunft ein wichtiges Thema zur Steigerung unserer Wettbewerbsfähigkeit hier am Standort.“

Karl-Friedrich Stracke 2016 (CEO, Magna Steyr Fahrzeugtechnik)

Feedback from industry 2/2

- Strategic agility:
  - How to implement agility?
  - How to be more agile on a strategic level? → New business models

- Operational agility
  - How to combine it with existing operational concepts?
  - Lean Production is a dominante concept in industry

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What is lean production?

- **Five main principles**
  - Value; value stream; continuous flow; perfection and transparency; and pull system
- **Tries to avoid…**
  - Waste: no value for customer (overproduction, waiting time, transportation, etc.)
  - Variation: deviations from standard
  - Inflexibility: meeting changing customer requirements without additional costs
- **Three main areas**
  - Operating System: smooth value stream of the product/service
  - Management infrastructure: management system with performance management
  - Mindset, behavior: staff and managers

Source: Womack et al. 2003; Drew et al. 2004

Summary of lean production in literature

- Lean Production is still playing a major role in manufacturing companies [Drew 2004; Jasni 2013; Bahmu 2014]
- Lean Production is continuously further developed [Papadopolou 2004]
- Markets are getting more volatile: “One of the key criticisms of lean has been the inability to cope with variability.“ [Hines et al. 2004]

Lean and agile production in literature

1a) Agility is the next step: Mass Prod. → Lean Production→ Agile Production
[Purvis et al. 2014; Hallgren, Olhager 2009; Narasimhan et al. 2006; Yusuf, Adeleye 2002]

1b) Many lean principles are required as base for agility
[Shahram et al. 2011; Christopher, Towill 2001]

2a) Choose between lean, agile, resilient or "leagile" supply chains
[Purvis et al. 2014; Lotfi et al. 2013; Stump, Badurdeen 2012; Hallgren, Olhager 2009; Goldshy et al. 2006; Agarwal et al. 2006; Vonderembse et al. 2006; Mason-Jones et al. 2000]

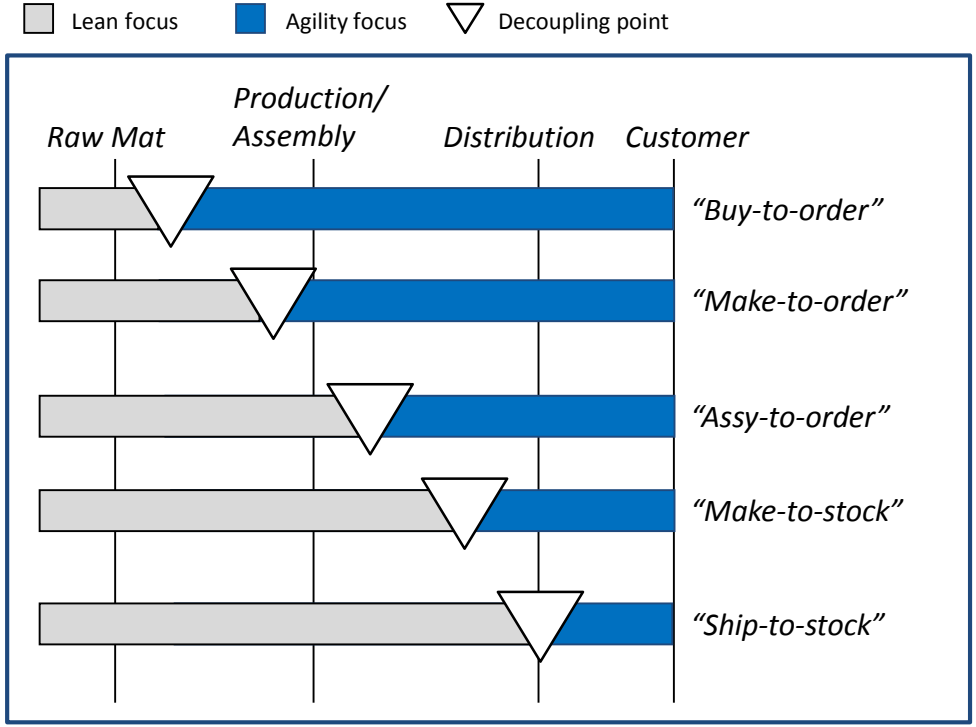
2b) Leagility is what is needed in today´s environment [Mukhopadhyay 2015; Nieuwenhuis, Katsifou 2015; Jodlbauer et al. 2012; Ambe, Badenhorst-Weiss 2010; Olhager 2010; Krishnamurthy, Yauch 2007; Towill 2005; Olhager 2003; Christopher, Towill 2001; Towill 2000; Naylor et al. 1999]

3) Lean is highly flexible and agility should be integrated into lean production
[Villa, Taurino 2013; Piazolo, Felderer 2013; Onyeocha, Geraghty 2012; Bohnen et al. 2011; Scherrer-Rathje 2009; Bell 2006; Drew et al. 2004]

Leagility – Lean and agile in a SC via decoupling point

Decoupling point

- **Separation** of supply chain
- Upstream based on **planning**
- Downstream **oriented to customer orders**



Source: Naylor 1999

Summary of lean and agile production in literature

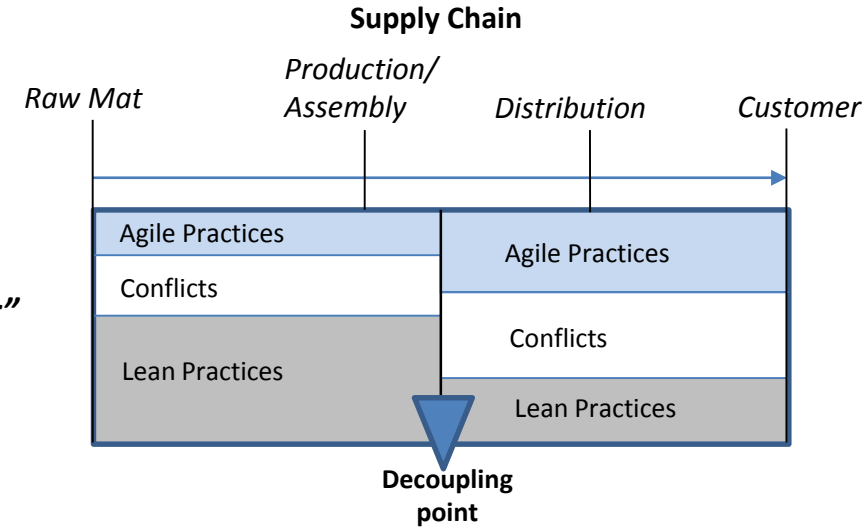
- **Different focus**
  - *Lean*: reduce cost / improve quality / reduce process time
  - *Agile*: increase service level / early anticipation / be prepared to adapt efficiently to changes / capture new opportunities
  - *Lean, agile, leagile:* Depending on market, product, company

- **Operational view**:
  - No clear insights in literature
  - Overlapping principles

Critizing the leagile decoupling point

- No clear distinction of lean and agility before and after decoupling point
- No operational perspective on differences between lean and agility

e.g. "Assy-to-order"



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Research gap

- Still gaps in applying and implementing combination of Lean and Agile Production [Bahmu 2014; Elmoselhy 2013; Putnik 2012; Naim 2011]
- *"More research is also required to distinguish the common and different elements of LM and Agile Manufacturing …"* [Bahmu 2014]
- *"The extent to which one paradigm fits into another, and the scope of the lean or agile paradigms, and the extent to which leanness is a prerequisite for agility and vice versa are still contested."* [Narashimha 2006]

→ **Operational perspective on implementing lean and agile production**

Research-guiding questions

1. Which lean tools (a) support agility, which (b) are in conflict with agility and which are (c) neutral?
2. Which agile tools are (a) in line with lean production and which (b) work against lean?
3. What are recommandations for implementing lean and agile tools?

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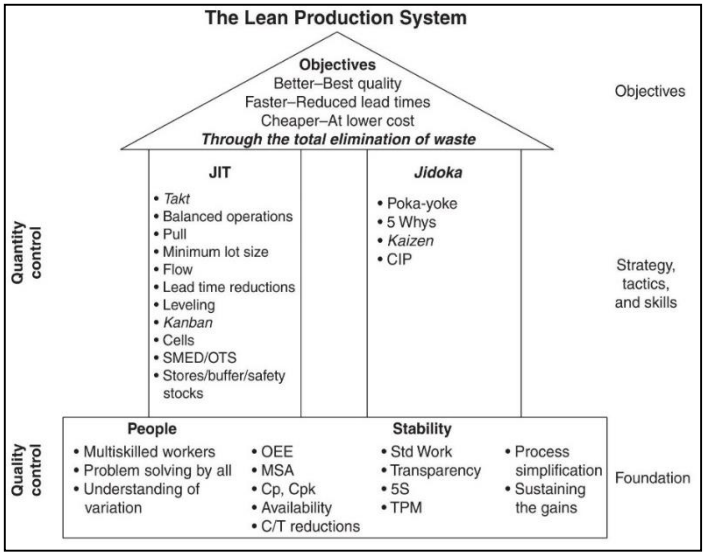
Lean tools and agility criteria

Lean tools



Source: Wilson 2010

Agility criteria

- **Short or long-term demand changes** (e.g. lead-time, changing capacity with connected effort and time, how long)
- **Variants and new products** (e.g. time-to-market, changing between variants with effort and time)
- **Quality** (e.g. required from customer)
- **Costs** (e.g. profitability)
- **Time** (e.g. delivery time)

Lean tools supporting or in conflict with agility

Supporting agility

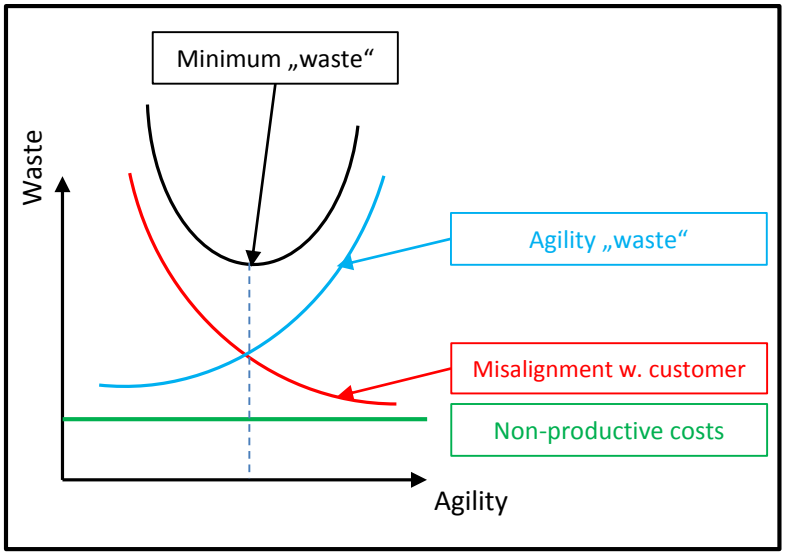
- Lead time reduction → demand changes
- Reduction of set up time using SMED → variants

In conflict with agility

- Takt time: Possibility to change takt time, due to changing demands
- Pull and Kanban:
  - Does not work properly in the case of fluctuated demand situations
  - BK CONWIP as new approach [Onyeocha 2012/2015]
- Elimination of waste
  - The aim to eliminate waste should still be emphasized
  - Careful consideration of capacities and stocks should be examined

Right level of agility

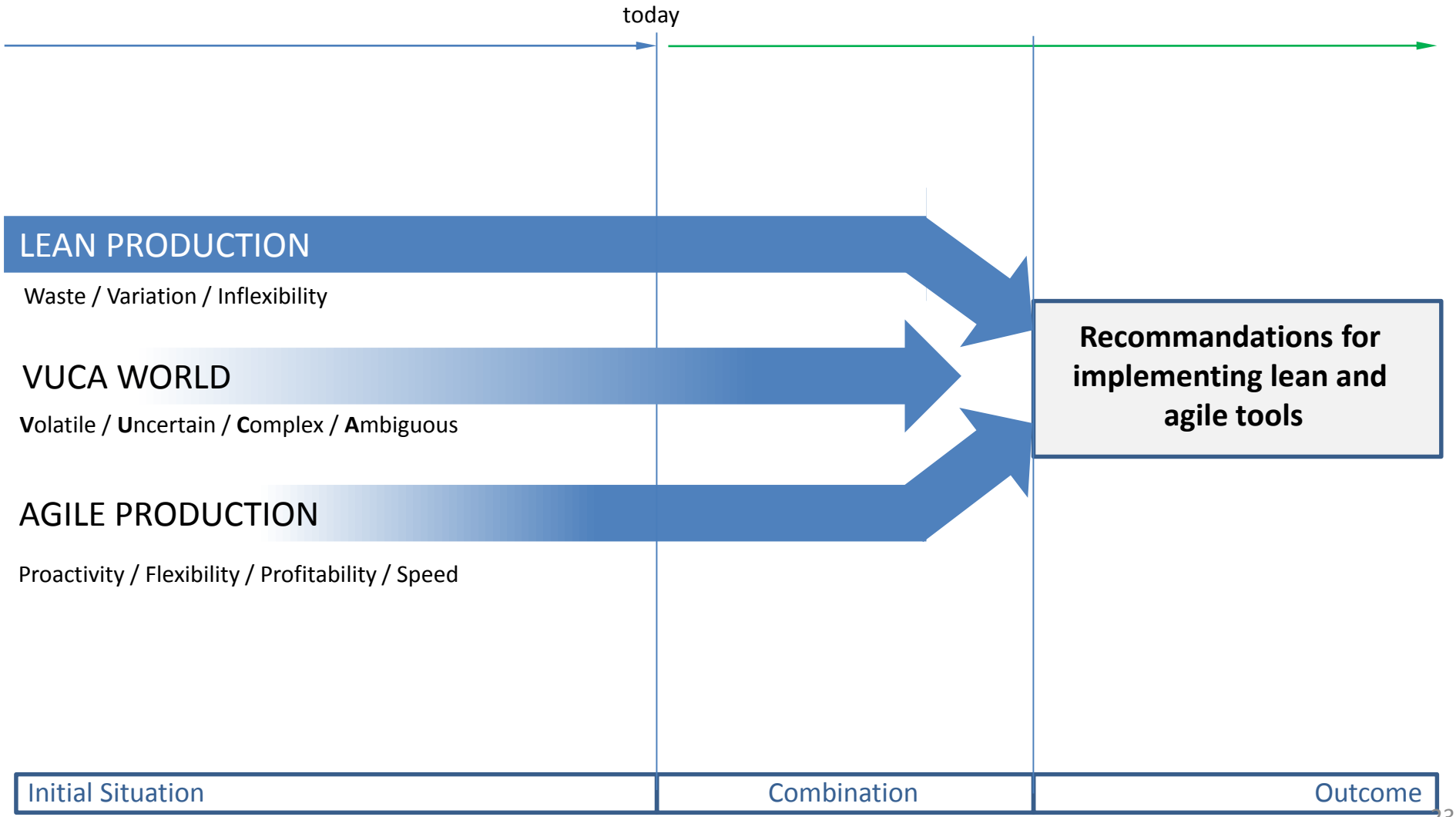
- As lean as possible, but as agile as necessary
- Coordination of lean and agile operational practices



Source figure: Putnik 2012

→ Through agility less waste because of meeting customer demand
→ Through agility more waste because of proactively investing money to react faster

→ **Combination: Minimum waste point**


today
LEAN PRODUCTION
Waste / Variation / Inflexibility
VUCA WORLD
Volatile / Uncertain / Complex / Ambiguous
AGILE PRODUCTION
Proactivity / Flexibility / Profitability / Speed
Recommandations for implementing lean and agile tools
Initial Situation
Combination
Outcome

Open questions

- How to validate agility tools regarding completness?
- Experiences with lean production and agility?

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Reinforcing lean production through agility aspects

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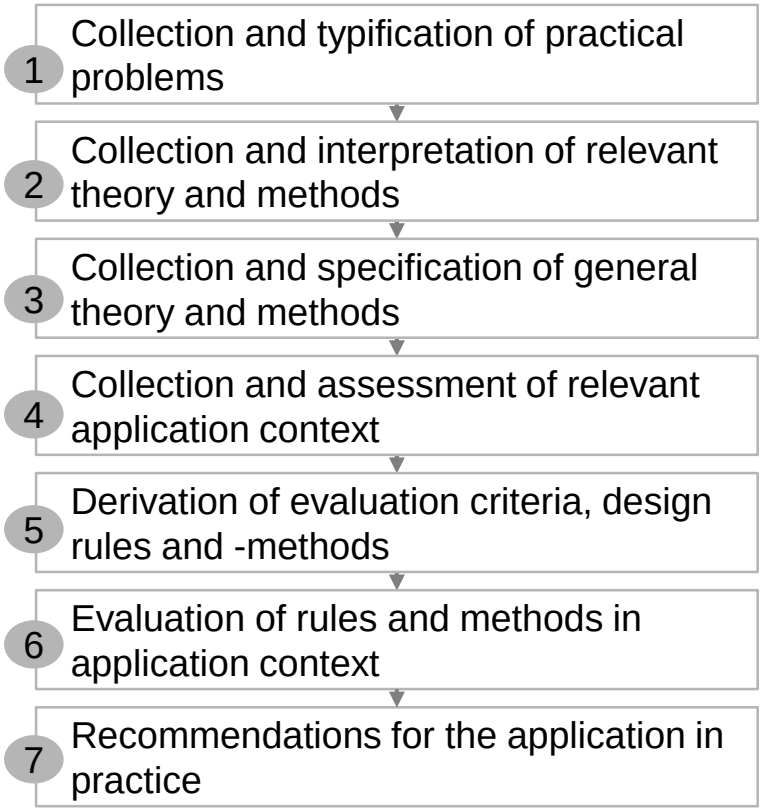
BACK UP

Research process by Ulrich



SOURCE: Ulrich, 1981

Lean and Agile Production - Literature

Differences
Agile calls for robustness characterized by taking advantage of fluctuating demand, while leanness avoids robustness by calling for stable demand and production levelling and smoothing [17].
The market winner for lean supply chain is cost, while other factors such as quality, service level and lead time are considered as market qualifiers. In the case of agile, however, service level distinguishes itself as a market winner, while cost, quality and lead time are market qualifiers [19].
With leanness market demand is predictable, while in agile it is volatile and non-predictable [20]. In addition, agile organizations should be more sensitive to customer demand [1].
Agile supply has superior performance in mixed volume and mix flexibility situations [6, 17].
Lean is suitable for standard products, lower varieties, with stable market and high cycle time, while agile is suitable for new innovative products [19, 21].
Dominant cost in agile is marketable cost, while dominant cost in lean is physical cost [20].
The degree of cooperation between companies is very high in agile, while it is considered low in lean [1].
Leanness establishes long term relations with shorter list of suppliers, while agile involves high number of suppliers with short term relations [22].
Product development in agile is significantly shorter than in lean; it takes weeks rather than months as is the case with lean [22].

Lean and Agile Production - Literature

Synergies and Similarities
Use of market knowledge, where the end user is highly emphasized and the supply chain is responsive [17].
Existence of integrated supply chain, value stream or virtual corporation [17], although agile calls for virtual collaboration which makes it possible to access global resources [23].
Reduction of lead time with equal importance [17, 20 ,1].
Elimination of waste “muda”. e.g. non value added activities, although it is essential in lean and desired in agile [17 ,20 ,1].
Rapid reconfiguration, although it is more desired in agile [1,17].
Leveraging employees, using IT for enhancing communication [8, 1, 19].
Both exhibit the need for skilled employees, although in agile the need is greater [1].
Both paradigms call for flat organization, although in agile, organizations should also be nimble and empowered to change in response to several situations [22].
Perfecting flow of material to achieve enhanced competitiveness [8].
The extensive use of similar concepts like Kaizen (Continues Improvement), TPM (Total Productive Maintenance) , TQM (Total Quality Management) with equal importance [24], and the use of JIT, concurrent engineering, quick changeover, cross functional teams [25].

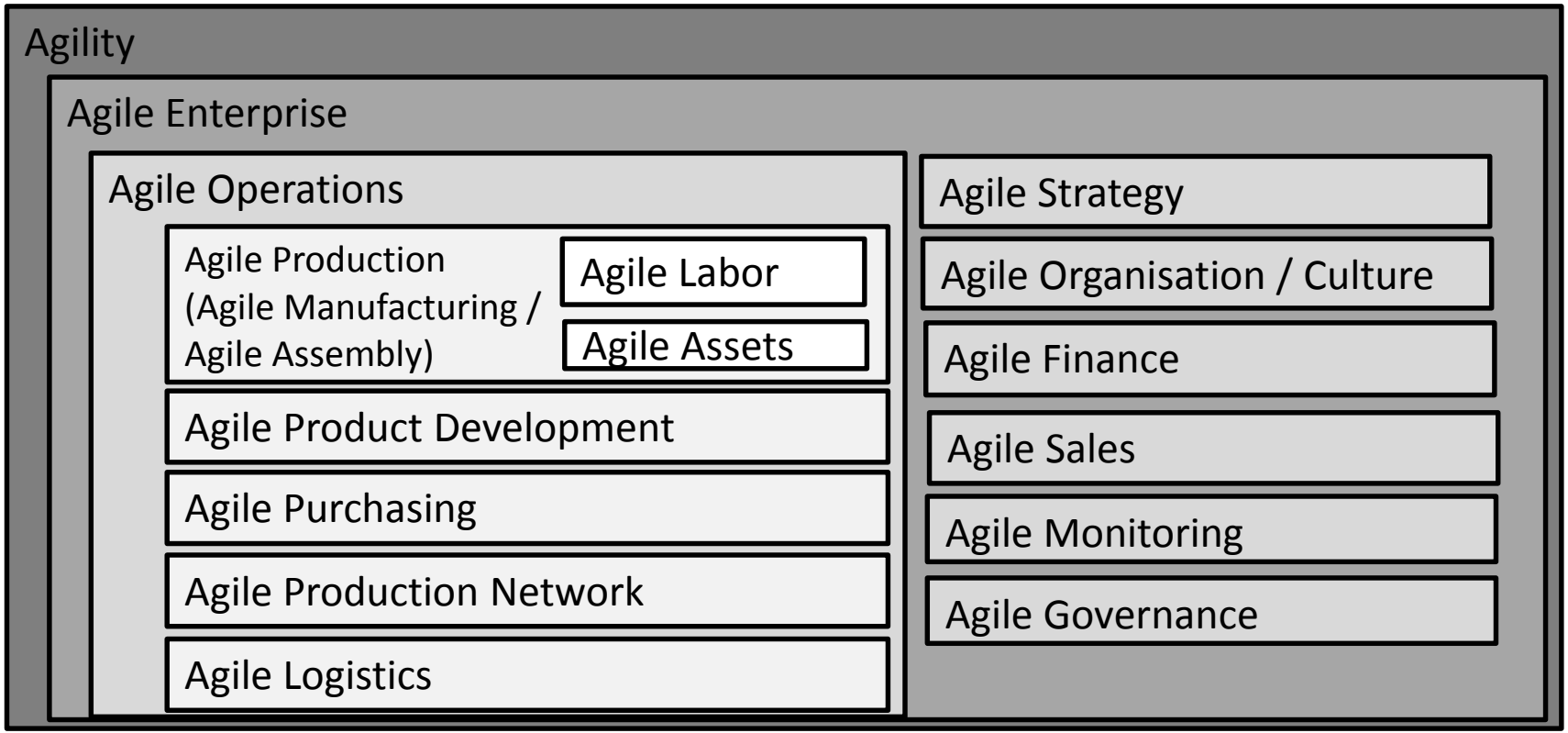
Operational practices of agile production

Labor / Human Resources	**Employee transfer** (job rotation, manning pool)
	No. of employees (Temporary workers)
	Work time flexibility (holidays, contracts time accounts, shifts extend or eliminate)
Logistics	**Adaptive Equipment** (adjustable container, standarization of warehouse equipment)
	Inventory management (small, inexpensive, centralzied vu deentralized)
Production network	**Adjustment of network in own side** (mini factories, flexible production network, more SC)
	Adjustment of management of overall network (decentralization, vertical integration)
Product Design	**Design products for manufacturability**
	Design products for raw material flexibility
	Development tools (3D printer, etc.)
	PEP (late product differentiation)
	Standardized components (modular, platform)

Purchasing / Supplier relationship	**Cooperation with suppliers** (safety stock, volume and price flexibility, preferred customer, agile supplier)
	Sourcing strategy (Agile end-to-end SC, multi-sourcing)
Assets & Process	**Adjust capacity/availability** (2 sites, leasing, new business models, peak shaving)
	Agile production technology (3D printing)
	Modularity
	Standardized production equipement
	Universal machinery (levels of automation)
	Production process (multiple takt times)
Sales	**Go to market** (outsource marketing)
	Supply demand matching

2) Comparison of Lean and Agile Production

Field	Lean Concepts (Nordin 2010, Gurumurthy 2009)	Agility (IBL research)
Purchasing / Supplier relationship	JIT delivery; Supplier quality level; Supplier involvement in quality improvement program; Supplier involvement in product design and development; Long term supplier relationship, Information sharing with suppliers	**Cooperation with suppliers** (safety stock, volume and price flexibility, preferred customer, agile supplier) **Sourcing strategy** (Agile end-to-end SC, multi-sourcing)
Assets & Process	Kaizen; 5S; Setup time reduction; Cellular manufacturing; Continuous flow; Equipment layout; Error proof equipment; Preventive maintenance; Use of multiple small machines; Workload or line balancing; One piece flow; Work standardization; Visual control; Single minute exchange of dies; Andon (warning lights); WIP reduction; Elimination of buffers; Cycle time and lead time reduction	**Adjust capacity/availability** (2 sites, leasing, new business models, peak shaving) **Agile production technology** (3D printing) **Modularity** **Standardized production equipment** **Universal machinery** (levels of automation) **Production process** (multiple takt times)
Manufacturing planning & control	Levelled production; Kanban/ pull production; Daily schedule adherence; Small lot size; Visual control; Production smoothing or load levelling; Storage space reduction	
Labor / Human Resources	Group problem solving; Training; Cross functional teams; Employee involvement; Workforce commitment; Safety improvement programs; Multi skilled workforce; Employee empowerment; Employee participation; Rewards and recognition; Job enlargement or Nagara system; Communication between employees; Job rotation or flexible job responsibilities	**Employee transfer** (job rotation, manning pool) **No. of employees** (Temporary workers) **Work time flexibility** (holidays, contracts time accounts, shifts extend or eliminate)
Logistics	Kanban; Standardized containers	**Adaptive Equipment** (adjustable container, standardization of warehouse equipment) **Inventory management** (small, inexpensive, centralized vs decentralized)
Production network		**Adjustment of network in own side** (mini factories, flexible production network, more SC) **Adjustment of management of overall network** (decentralization, vertical integration)
Product Design	Lean Innovation, Lean Product Development, Product design – simplicity; Design-for-Manufacturing, Product and process simplification; Commonization and standardization of parts; Modular design; Concurrent engineering; Supplier involvement in design; Computer integrated manufacturing (CAD/CAM/CAE)	**Design products for manufacturability** **Design products for raw material flexibility** **Development tools** (3D printer, etc.) **PEP** (late product differentiation) **Standardized components** (modular, platform)
Sales / Customer relationships	Customer involvement in quality programs; Customer involvement in product design; JIT link	**Go to market** (outsource marketing) **Supply demand matching**


Agility
Agile Enterprise
Agile Operations
Agile Production
(Agile Manufacturing /
Agile Assembly)
Agile Labor
Agile Assets
Agile Product Development
Agile Purchasing
Agile Production Network
Agile Logistics
Agile Strategy
Agile Organisation / Culture
Agile Finance
Agile Sales
Agile Monitoring
Agile Governance

Lean tools supporting agility

Lean tools	Mapping with lean house [12]	Description and Relation to flexibility
Supermarket	JIT pillar - Stock/buffers/ and safety stock	Achieves flexibility when customer lead time is shorter than the product lead time [11]. It is categorized as banking flexibility [27].
Over capacity	JIT pillar - Stock/buffers/ and safety stock	Categorized as banking flexibility [27].
Visual management, andon, and 5S	Foundation Pillar- Transparency Jidoka, 5S	Ensuring transparency and the effective movement of staff [11], and categorized as adaptation flexibility [27].
Standardization	Foundation Pillar- Standard Work	Supports flexibility through insuring training of employees and allowing employees to be switched in the case of fluctuations [11]. It is categorized as adaptation flexibility [27].
Cellular manufacturing	JIT - Cells	Supports responsiveness and flexibility by easier and faster planning of the workforce on field, fewer employees required [31], [12, 32], and categorized as adaptation flexibility [27]
Lead time reduction	JIT Piller - Lead time reduction	Reducing the lead time enables the company to respond faster to abnormalities, for instance, when changing the product mixes [12]. It is categorized as adaptation flexibility [27]
Reduction of set up time using SMED	JIT Pillar- SMED/OTS	Categorized as adaptive flexibility [27]
Multifunctional employees	Foundation Pillar -Multiskilled workers	Employees are trained to perform a variety of tasks/jobs and they are cross-trained so that they can fit to other tasks if necessary [33]. This achieves adaptation flexibility [27,34].
Total Productive Maintenance (TPM)	Foundation Pillar - TPM	TPM contributes in increasing the availability and reducing uncertainties, and helps be flexible to changes in volumes [34]. It is categories as adaptation flexibility [27].
One piece flow, Minimum lot size	JIT Pillar- Flow, Minimum lot size	Is considered the key to flexibility, and prompts responsiveness; when reducing the lead time for the a lot or piece, discovering mistakes is faster [12].It is categories as adaptation flexibility [27].
Kaizen and communicating improvements	Jidoka-Kaizen and Continuous Improvement Foundation- Transparency	It is categories as adaptation flexibility [27].
Poka-Yoke	Jidoka- Poka Yoke	It supports mistake proofing, and thus, enhances the robustness of processes [12]. It is categories as adaptation flexibility [27].

Tailored lean tools to prompt agility

Current lean tool	Tailored tools agility
Takt time	Scenario based takt time: Due to the variations in demand, the planning system, should enable the operational takt time to be recalculated on weekly bases, and in case of changes due to increases in demand, swift reallocations can be undertaken e.g. adding a worker to the cell [35]. Thus, different scenarios should be planned [5].
Pull and Kanban control strategy	Tailored Kanban systems e.g. Hybrid BK CONWIP, Push-Pull: One of the drawbacks of Kanban is that it does not work properly in the case of fluctuated demand situations [36]. This drove scientists to develop the Kanban system by decoupling Kanban signals and demand information, creating a push pull strategy, and adding CONWIP cap to control to the system WIP. Such approach is called BK COWNIP, and works better in erratic demand and multi stage, multi-product situations [37,38].
Elimination of waste	Careful elimination of waste: The aim to eliminate waste should still be emphasized in flexible lean supplies. However, careful consideration of capacities and stocks should be examined to have a robust system susceptible to changes in customer demand [17].
Line balancing	Scenario based line balancing: The uncertainties exist in flexible environment calls for using models that are more robust in line balancing. Some scientists developed scenario planning techniques based on worst scenario and planning to cope with such environments [39].
Levelling production	Adaptive level production: Usually levelling production aims at finding a fixed pattern over the leveling period. Nevertheless, changes in demand mixes are common, and thus the system should be robust to react to such changes, and if needed the pattern should be adapted. In such situations, forecasting is important to decide the patterns and periods. [40]. One of the key issues to facilitate this adaptation is to have set-up friendly production facilities such as CNC or flexible manufacturing systems, this would enable the company to modify the production sequence more easily e.g. A,B,E,D to A,E,E,D [41].