Appendix - MAP 4.0 – Proposal of a prescriptive Maturity Model for assessing the Digitalization of Procurement

Table 3. Evaluation of existing Maturity Models
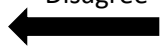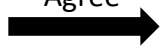
Author(s)	Description	Applicability to procurement	Inclusion of all relevant Industry 4.0 technologies	Description of Assessment Method	Clear and comprehensible	Definition of Target State
Asdecker & Felch (2018)	Three dimensions for assessing the maturity of delivery logistics in the context of Industry 4.0 in five levels.	✖	✖	✔	✔	✔
Bibby & Dehe (2018)	Maturity levels of defense industry companies in the context of Industry 4.0 with 23 elements from 3 dimensions with 13 sub-categories in four levels.	✖	✔	✖	✖	✔
De Carolis et al.(2017)	Maturity model based on 18 elements from 5 company-wide dimensions in the context of Industry 4.0 in five levels.	✖	✖	✖	✔	✖
Facchini et al. (2020)	Maturity model for logistic companies in the context of Industry 4.0, based on seven logistics-specific dimensions in five levels.	✔	✖	✔	✔	✖
Ganzarain & Errasti (2016)	Maturity model for SMEs and deriving future needs for action in connection with Industry 4.0 in five levels.	✔	✖	✖	✔	✖
Geissbauer et al. (2016)	Maturity model in the context of Procurement 4.0 based on six dimensions, 20 sub-components and eight additional environmental factors in four levels.	✔	✔	✖	✔	✖
Gökalp et al. (2017)	Extension of an existing Industry 4.0 maturity model in six levels.	✖	✖	✖	✖	✔
Jæger & Halse (2017)	Model for the assessment of Internet of Things (IoT) with six dimensions in eight levels.	✖	✖	✖	✖	✔
Jodlbauer & Schagerl (2016)	Maturity levels based on data, intelligence, and digital transformation, including definition target states in ten levels.	✔	✖	✖	✖	✔

Katsma et al. (2011)	A model that presents the advances of IoT in the field of logistics and utilities in four levels.	✘	✘	✘	✔	✔
Kleemann & Glas (2017)	A model focusing on the degree of digitization of purchasing based on the scale value of a questionnaire with eight dimensions and three maturity criteria, each in five levels.	✔	✘	✔	✔	✘
Klötzer & Pflaum (2017)	Model for SCM companies based on smart product realization and smart product application in five levels.	✘	✘	✘	✔	✔
Kosmol et al. (2019)	Maturity model in the context of development towards Procurement 4.0 based on eight different dimensions in five levels.	✔	✘	✔	✘	✘
Leineweber et al. (2018)	A model with any number of characteristics in 3 dimensions and relationships between corresponding characteristics in eight levels.	✘	✘	✘	✔	✔
Leyh et al. (2016)	Model for assessing the IT architecture companies in 4 different dimensions (with seven guidelines) in eight levels.	✘	✔	✘	✔	✔
Lichtblau et al.(2014)	A model with a maturity level calculation within six different dimensions based on corresponding criteria matrices in six levels.	✘	✔	✔	✔	✘
Merz (2016)	Positioning of the company based on an alignment of corporate strategy & previous Industry 4.0 experience in a 4-part matrix utilizing 3C –analysis in five levels.	✘	✘	✔	✔	✔
Pacchini et al. (2019)	Maturity levels based on the average assessment of eight dimensions with a focus on innovative technologies in six levels.	✘	✔	✘	✔	✔
Pellengahr et al. (2016)	A model for evaluating the maturity of procurement departments based on four different dimensions to 40 subcomponents in seven levels.	✔	✘	✔	✔	✘
Pessl et al. (2017)	A model evaluating the actual and target status in 13 dimensions for assessing one's own HRM's maturity level concerning Industry 4.0 in five levels.	✘	✘	✔	✔	✔

Pirola et al. (2019)	Model for calculating the maturity level of SME in the context of Industry 4.0 based on an index of any number of elements from five dimensions in five levels.	✘	✘	✔	✔	✔
Pongsuwan (2016)	Maturity model procurement departments in the context of Industry 4.0 and e-procurement based on six dimensions and 22 subcomponents in four levels.	✔	✘	✘	✘	✘
Santos & Martinho (2019)	A model with an assessment of maturity level based on 34 evaluated elements from five different dimensions in six levels.	✘	✔	✔	✔	✘
Schuh et al. (2017)	Layer model with four dimensions for assessing the current and target states and comparison with competitors in six levels.	✘	✘	✔	✔	✔
Schumacher et al. (2016)	A model with a maturity level calculation based on weighted average using 62 different maturity items in nine dimensions in five levels.	✘	✘	✔	✔	✘
Sternad et al. (2018)	Model for determining companies' maturity in the context of Logistics 4.0 based on four dimensions and a variable number of sub-components in five levels.	✘	✘	✘	✘	✔
Akdil et al. (2018)	A model with 13 different maturity elements from three dimensions (smart products and services, smart business processes, strategy and organization) in four levels.	✘	✘	✔	✔	✔
Wagire et al. (2020)	Model for the weighted calculation of the maturity level for seven dimensions in the context of Industry 4.0 employing 38 evaluated elements in four levels.	✘	✔	✔	✔	✔
Watzlawek (2018)	Maturity model with eight dimensions for procurement departments in the context of Industry 4.0 in four levels.	✔	✘	✔	✘	✘
Weber et al. (2017)	A maturity model for data-driven manufacturing and the IT architecture in the company in the context of Industry 4.0 in six levels.	✘	✘	✘	✔	✔

Werner-Lewandow-ska & Kosacka-Olejnik (2019)	A maturity model for companies or industries based on their system landscape and structural adaptation in logistics as a service in six levels.	✖	✖	✓	✓	✓
Westermann et al. (2016)	A maturity model for cyber-physical systems in mechanical engineering and individual CPS components in five levels.	✖	✖	✓	✓	✓

Table 4. Questionnaire 1

Dimension/ Question	0	1	2	3	4	5
		Disagree ←			Agree →	
Dimension **Networking**						
Purchasing has a system that seamlessly records the internal added value using data and enables it to be evaluated.						
Purchasing uses digital collaboration platforms internally and enables the mobile, proactive and structured exchange of knowledge.						
Digital collaboration platforms are used between purchasing and suppliers, reducing complexity and redundancies.						
Dimension **Supplier Relationship**						
There is a concept for digital supplier integration.						
Supplier relationships are also differentiated and assessed with regard to their digital potential.						
When working with suppliers, there are standards for digital forms of collaboration.						
Dimension **Purchaser**						

The development of function-related digital expertise is a central part of employee development in purchasing.					
The purchaser is experienced in handling his/her own digital products and use them.					
When recruiting new purchasers, function-related digital skills are an important selection criterion.					
Dimension **Organization**					
Digitalization in purchasing has operational management (responsibilities).					
Digitization projects in purchasing are processed across functions and with partners (including consultants, start-ups, research).					
Purchasing has sufficient resources to be able to process digitalization/ innovative topics in normal business operations.					
Dimension **Autonomous Processes**					
The workflow for regular orders is automated					

within certain specifications - without human work (approval, control).					
Warehouse range, value, required quantity, order frequency and other parameters are analyzed automatically (big data).					
Automated analyzes of order data are used to initiate forecast-based orders (predictive analytics).					
Dimension **Product Group Strategy**					
Purchasing is proactive in searching for suppliers and products in the field of new, innovative technologies to anticipate changing requirements.					
There are product groups (strategies) for purchasing digital services (software, licenses, CAD drawings, documentation, rights).					
Purchasing investigates the effects of 3D printing with regard to the make-or-buy question (insourcing options).					
Dimension **(Digititalization-) Strategies**					
There is a digitization strategy for your own					

company/organization as a whole.					
There are guidelines and priorities regarding what contribution digitized purchasing 4.0 has to make for the company/organization.					
Purchasing brings its market and supplier know-how to the digitization strategy (purchasing innovations and 4.0 technologies).					
Dimension **Company-IT**					
The company's IT is regularly updated to meet new challenges.					
The in-house IT specialists advise purchasing on digitalization.					
Data security and IT security, in general, are ensured through risk analyzes and measures.					

Table 5. Questionnaire 2

Dimension/ Question	Lowest level of maturity			Highest level of maturity	
	1	2	3	4	5
Dimension **People and Culture**					
Management supports Digitalization activities.					
The corporate culture of continuous adaptation to Industry 4.0					
The existence of special teams to advance digitization in the company.					
The company's orientation towards adapting and promoting the skills of its employees concerning Industry 4.0.					
Dimension **Perception of Industry 4.0**					
The familiarity of the term "Industry 4.0" in the company.					
The company's perception of the change brought about by Industry 4.0.					
The company's perception of the advantages of Industry 4.0					
The perception of the company's willingness to implement new technologies.					
Dimension **Corporate Strategy**					
The company's digital vision and roadmap for Industry 4.0					
The company's ability to integrate the customer's wishes into product development.					

The company's efforts to promote the transformation of Industry 4.0 through external companies.					
The company's ability to ensure paper-free data storage.					
The company's investment in Industry 4.0					
Dimension **Value chain and processes**					
The degree of digitization from product development to the finished product.					
The ability of the company to display the production of the items in real-time and to react to changes.					
The level of continuous technological support from planning to logistics.					
The technological level of the production equipment.					
The digitization of the value chain from the supplier to the end customer.					
Dimension **Intelligent Manufacturing Technologies**					
The use of advanced autonomous robots.					
The use of digital software for collecting, processing and passing on information.					
The use of technical possibilities for the permanent location of components, machines and products.					
The use of intelligent sensors to monitor the production process.					

The use of communication technologies to pass information between machines.					
The provision of a digital platform for integrating suppliers.					
The provision of a digital platform for integrating customers.					
Dimension **Product and Service-oriented Technologies**					
The use of technological devices to visualize product-dependent information (VR)					
The use of 3D printing in the company.					
The use of mobile devices to share information.					
The use of "blockchain technologies" in the company.					
The development of intelligent products that can perceive their surroundings using sensors.					
Dimension **Basic Industry 4.0 Technologies**					
The use of "cloud computing" to share resources and information.					
The use of "cloud computing" to store information and data.					
The use of communication technologies for the wireless exchange of information between people, machines and systems (Internet of Things).					
The use of internet-based technologies for mutual value creation with others (internet of services).					

The company can store, analyze and process large amounts of data in real-time (big data).					
The use of simulation tools to generate potential scenarios.					
The use of technologies based on artificial intelligence (AI).					
The use of various IT security measures to ensure the security of data and information.					

Table 6. Questionnaire 3

Dimension/ Question	0	1	2	3	4	N
	Disagree				Agree	
Dimension Employee						
The employees in purchasing have the knowledge and understanding of the basics of Procurement 4.0.						
The employees in purchasing know and understand the advantages of Procurement 4.0 for your department or your company.						
The employees actively support the change towards Procurement 4.0.						
The employees have the necessary skills in dealing with new technologies.						
The employees are extensively trained in new systems and technologies.						
The employees are open to new technologies.						
The employees have an autonomous way of working.						
Flexible new work models are offered to employees.						
The employees are encouraged to interact in an interdisciplinary manner.						

Dimension **Corporate Strategy and Culture**						
The company management understands and recognizes the upcoming change through Industry 4.0 (Procurement 4.0) and acts accordingly.						
The company has a clear digitalization strategy for the change towards Industry 4.0 (Procurement 4.0).						
The procurement department has sufficient defined resources available for the change.						
The company communicates the advantages of Industry 4.0 (Procurement 4.0).						
The company continually monitors the progress of change and informs the organization.						
The company adapts its business model to the requirements of Industry 4.0 (Procurement 4.0).						
The company also involves external partners in the implementation of their change.						
The company involves the entire organization in the change.						
The company promotes open innovations.						

Dimension **Organization and Processes**						
The regular order initiation is automated.						
The conclusion of sales contracts takes place based on automated decision support.						
The conclusion of sales contracts is done automatically by the system.						
The relevant key figures for procurement, such as warehouse coverage, supplier data and order processes are automatically collected.						
Future requirements are automatically calculated based on past data and other environmental influences.						
The relevant information from the procurement department is always available in real-time.						
The modeling of potential scenarios is automated based on digital data.						
The supplier evaluation takes place automatically based on historical data.						
The future value of suppliers is forecasted by the system.						
The integration of suppliers into existing systems is essential for cooperation.						

The organization of procurement is becoming increasingly decentralized.					
Cooperative collaboration both within and between the departments is encouraged.					
The implementation of Procurement 4.0 is accompanied and documented by a designated person in the procurement department.					
The implementation of the concepts in the context of procurement 4.0 takes place with the support of external partners.					
Dimension **IT Structure and Industry 4.0 Technologies**					
Digital security plays a key role in corporate IT.					
The networking and transfer of information within all departments are guaranteed continuously.					
Special software is available for procurement, which is geared to the processes of the department.					
The risk of system failure is low due to security measures.					
The use of mobile devices within the company is guaranteed without any problems.					
The IT hardware is permanently able to operate at the highest level.					

The IT staff permanently supports the procurement department in the change towards Procurement 4.0.						
The internal IT guarantees permanent access to all relevant data in real-time.						
The systems of procurement and suppliers can communicate with one another without any problems.						
Data collection and analysis in procurement are automated.						
The use of "cloud computing" enables the department to share resources and information and store data.						
Procurement recognizes the potential of Blockchain technology and is ready to use it.						
The new communication technologies for the wireless exchange of information between people, machines and systems are used (Internet of things).						
The shared value creation with others is partly based on internet-based technologies (Internet of Services).						
The company analyzes, stores and processes large amounts of data in real-time (Big Data & Web Analytics).						

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The use of simulation tools enables the generation of potential scenarios for decision support.					
The use of technologies based on artificial intelligence supports procurement in its activities (Artificial Intelligence AI).					
Procurement recognizes the potential of 3D printing and is ready to use it.					

Please mark the actual status in blue   **Please mark the target status in red**

In your opinion, which questionnaire is best suited to capture the relevant factors in the context of Procurement 4.0?