ANALYSIS OF REFERENCE MODELS FOR PRODUCTION AND LOGISTICS PLANNING

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1 Production and Logistics Planning in Business Practice

The principles underlying production systems have been subject to a rapid change since the beginning of the 20th century [1]. As a result, from the perspective of production and logistics, new challenges emerged in the design in terms of organizational structures and procedures and their IT support. For instance, the principles and methods of lean production are state of the art for the design of modern and efficient production systems [2], [3]. At that point some issues are currently identified in the design and implementation of lean production in a company:

The individual elements of a lean production system are often considered isolated. Thus, the interdependences in the design are not worked out clearly enough. Among other things, this lack of systemic view results in untuned local optima, which in turn lead to unsatisfactory success of the overall system [3].

Another problem is the often unsystematic use of lean methods and principles. Mainly in the 90s this resulted to the fact, that large companies implemented their own interpretations of lean production. As a result, particularly original equipment manufacturers (OEMs) introduced a holistic production system at the beginning of the 21st century. In the context of a holistic production system the lean methods and principles are coordinated and systematically implemented in a company [4], [5].

Furthermore, the current state of the development of production and logistics planning is generally characterized by a great asynchrony and inequality between the individual companies. On the one hand, a business group of early adopters (based on the innovative planning and design of their production systems) exists by the automobile manufacturers and major OEMs in other industries (e.g. Siemens, Bosch, Airbus). On the other hand, many manufacturing companies, especially small and medium-sized enterprises (SMEs), are at the beginning to develop production and logistics processes specifically and systematically. These stragglers still deal with basic questions, such as, whether and which lean methods and principles are suitable for the design of their production and logistics processes. This issue results in a further deficit: the very different degree of maturity of the implementation of a holistically designed production system across all industries and company sizes. [2], [4].

2 Publications about Lean Production

In addition to the practical problems, three deficits are identified in the publications about lean production [6]:

- a lack of consistent, interconnected and interrelated description of the topic
- an adequate formalization in the form of information models
- a company-wide neutral representation that can also be used by SMEs

3 Reference Modeling as a Solution

At this point, reference modeling (from the field of computer science in economics) provides a way to create a clearer and intersubjectively comprehensible understanding of the issues in science and practice. The potentials and benefits of reference modeling in the field of production and logistics planning are very great, because it enhances the effectiveness and efficiency of practical planning projects. In addition, the lean philosophy is further developed as an engineering discipline by the potentials of reusability, which are increased based on the reference models [7]. Moreover, the use of semi-formal modeling languages enhances the degree of formalization of the often only textually present lean production approaches.

4 Research Questions

Due to the high potential of the use of reference models in the field of lean production, it is important to clarify how the current state is represented of reference models in production and logistics planning. Thus, a clear picture is provided of the current formalized references and concepts in the area of modern production systems design, a domain, which is characterized by a great asynchrony and inequality. Subject of investigation is, whether the reference modeling is generally used as a tool in production and

logistics planning and which elaborations are already suitable as reference models. Accordingly, this paper is based on following research questions:

RQ1: Which reference models are describing the current state of business practice of manufacturing companies in production and logistics planning?

RQ2: What gaps and potentials for development can be identified in the current reference model portfolio?

5 Research Method: Literature Review

The choice of research methodology is directly related to the research questions. The literature review is considered as the appropriate research method, because the research questions aim at the current use of reference models in production and logistics planning [8].

5.1 Literature Review Procedure

The Framework of VOM BROCKE et al. is used for the literature review to meet requirements of a methodologically sound and scientifically appropriate way of working with literature analysis [9]. Fig. 1 shows the procedure.

Figure 1: Framework for literature reviewing [9], [6]

The detailed literature review is described in SCHUBEL et al. [6]. The present paper focuses on the framework conditions and the analysis of results.

5.2 Basic Conditions for the Literature Review

The following description of conditions and limitations of the literature review population meets the demands of a systematic approach [10]:

- Limitation of the population:

A limitation of the population must be carried out by description of the special features, which objects must have, to count to the population. The research questions aim at the current state of industrial practice in production and logistics planning. Thus, only models count to the population, which are actually used in practice. Consequently, a clear limitation of the information models, which count to the population, can be made by the use-oriented reference model concept by THOMAS [11]. The use-oriented reference model term results in the following difficulties in the search for reference models. On the one hand, the declaration of located reference models as such, is not a sufficient criterion to count to the population. Instead, documentation is needed of at least one use case. As a result, the orientation on the term “reference model” is only restricted helpful. On the other hand, it isn’t practical to cover all kinds of models, which have been used once as a reference (hence they counted as use-oriented reference models). Since, this subset includes reference models with various properties, from non-formal through to not publicly available company-owned reference models [11]. To this end, the identified reference model portfolio is only representative but never entire.

- Objective Limitation:

The research focuses on the production and logistics planning of manufacturing companies and in particular on models that address the design of the company's production system and its processes (cf. Chapter 1).

- Time-wise Limitation:

The term "lean production" is characterized by the study "The machine that changed the world" by WOMACK, JONES and ROSS published in 1990 [12]. The study describes in particular the increased competitiveness of Toyota by lean production.

Thus, the following research contains only reference models with an application in practice in 1990 or later. The documented year of application of the reference model is to be used as the critical date. Consequently the used reference-models are excluded, which for sure are not affected by lean production principles and methods. Hence, the research focuses current models, which are influenced by modern production and logistics benchmarks.

6 Analysis Results

The presentation of the quantitative results of the literature review follows the definition of the keywords used for searching.

Databases	Total results by using all keywords	As relevant identified articles
EBSCOhost	68	**7**
Bibliotheksverbund Bayern	126	**37**
SpringerLink	3736	**59**
HMD-Praxis der Wirtschaftsinformatik (WISO-Database)	6	**0**
Wirtschaftsinformatik (Springer Link)	6	**0**
ZWF-Zeitschrift für wirtschaftlichen Fabrikbetrieb (WISO-Database)	77	**9**
Industrie Management (WISO-Database)	27	**8**
Sum of relevant articles (without redundant search results):		**108**

Table 1: Literature basis and quantitative search results [6]

The focus of research is on the identification of reference models in the field of production and logistics planning of manufacturing companies. Not all existing reference models are declared as such, according to the term understanding of the use-oriented reference models (cf. Section 5.2), Consequently, next to “reference model” the used keywords are the terms „best practice“ and „common practice“. Thus, the model use cases are captured, where the reference models are not declared as such, but still fulfill the criteria of a use-oriented reference model. The three terms mentioned are to conjugate with the domain-specific terms "logistics planning", "production planning" and "factory planning" in the keyword search.

The keywords were searched in the databases “Bibliotheksverbund Bayern” (ger/eng), “SpringerLink” (ger/eng) and “EBSCOhost” (eng). Based on the review of use-oriented reference models a specific search is effective in application-oriented journals of business informatics (HMD, Wirtschaftsinformatik) and production and logistics planning (ZWF, Industrie Management).

Table 1 shows the results using all combinations of keywords [6]. Articles are identified as relevant if they contain a model-like description in the context of production and logistics as well as at least one-time application of the reference.
The review was conducted by spotting in order title, index and abstract. If the title and index preclude the publication for further analysis, the search result is discarded without reviewing the index or the abstract.

A total of 108 articles has been identified as relevant and particularly analyzed [6].

6.1 Analysis by Date of Publication

The analysis by date of publication of the identified articles shows the increasing examination of formalizations of production and logistics know-how by use-oriented information models (Fig. 2). The literature review was executed in July of the year 2014, so the number of publications is to be regarded as incomplete for this year.

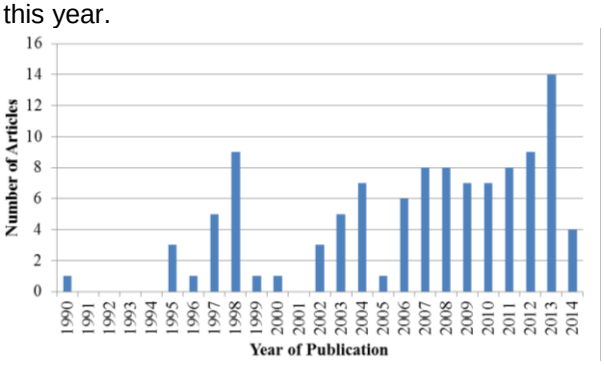

Figure 2: Literature basis by date of publication

6.2 Thematic Spectrum of the Articles

The 108 as relevant identified articles represent a broad and heterogeneous spectrum in the field of production and logistics planning of manufacturing companies. Below, the publications are assigned to thematic clusters.

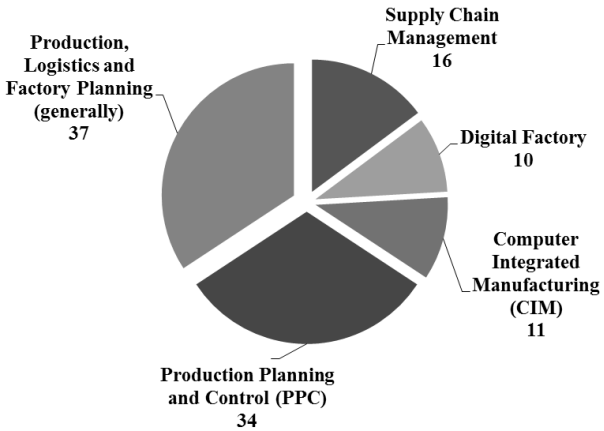

Figure 3: Topics of the identified articles [6]

Figure 3 illustrates the clusters formed by the identified articles. The use-oriented information models, which are generally assigned to production, logistics and factory planning, are the largest subset. In this first step of systematizing it is not meaningful to differentiate the articles of this cluster more specific, because an overview is purposeful on an appropriate high level of aggregation. Apart from this very general model group, thematic clusters are built, which relate to

production planning and control (PPC), computer integrated manufacturing (CIM), digital factory and supply chain management [6].

6.3 Analysis of the Thematic Clusters

At this point, the individual clusters are analyzed in more detail (Tab. 2):

– Supply chain management:
Supply chain management (SCM) focuses on the inter-company information and material flows. Thus, the reference models of SCM address the optimal integration of the entire (global) value chain from the supplier to the OEM up to the customer. The design of the processes of a single production system is not in focus, but the information systems within an enterprise network. The identified reference models describe, among other things, mathematical models, planning methods and frameworks [6]. For example, the supply chain operations reference (SCOR) model has acquired special relevance [13].

– Computer integrated manufacturing (CIM):
The reference models in the field of CIM deal mainly with solutions and concepts for the integration of information, data and progresses of the order processing and the product development process [6]. The actual design, planning and determination of production and logistics processes for efficiency criteria are ignored. Basically, the CIM concept and modern views of lean production do not exclude. However, the main application of lean production is the design of organizational structures and procedures, in contrast, the CIM concept foregrounds information technological methods and tools [6].

– Digital factory:
The generic term "digital factory" emerged from the development progress in the area of CIM. The number of digitized planning activities and objects increased due to the rapid growth of computer capacity [14]. A general term determination of the digital factory is incomplete because of the current existing diversity of edited application and research themes in this field.
The integration and standardization of methods and tools and their interfaces in the context of factory planning are general similarities in the vision of the digital factory. Also, the communication (interface management) along the factory life cycle is considered to support the product development process and factory planning process [15]. Finally, the aim is a consistent, redundancy-free and efficient data management. Thus, the digital factory is regarded as a link between the different planning processes of production, logistics and factory planning and includes both, the product development process and the customer order process. The actual design of the performance processes is not in focus. The identified reference models of the digital factory are mainly data models, planning methods and basic frameworks [6].

– Production planning and control (PPC):
The focus of the identified articles in the field of PPC is on the whole technical order processing. This process extends from the tendering to the distribution of a manufacturing company. From this perspective, production planning means not the physical design of the production processes, for example by choosing the appropriate storage technology or machines, but the planning steps in the order processing. It is typical for the PPC to expect existing conditions, such as a production system. The actual design is excluded of the production and logistics progresses of the system [6].

– Production, logistics and factory planning (generally):
The articles in the field of production, logistics and factory planning are characterized by a very low degree of formalization. The majority of publications describing profound and comprehensive concepts of the application

	Cluster	Supply Chain Management	Computer Integrated Manufacturing (CIM)	Digital Factory	Production Planning and Control (PPC)	Production, Logistics and Factory Planning (generally)
Focus	**system and data integration**		x	x		
	technical order processing				x	
	inter-company process design	x				
	planning activities and related methods					x
	Gaps / Potentials	no process design within a production system	no design of production and logistics processes for efficiency criteria	focus only on data and interface management as a part of factory planning	no actual design of the material flow in a production system	Solutions for process design with a very low degree of formalization and often without consideration of interfaces and interdependencies
	Example	SCOR-model [13]	Y-CIM-model [16]	DiFOR-model [14]	Aachener PPS-model [17]	Adaptive Logistics Planning [18]

Table 2: Analysis of the thematic clusters

domain, but this in a non-uniform way up to sheer textually formulated elaborations. The various concepts show a number of possible solutions for process design. Yet, they do not give an adequate support for the construction of a situationally optimal model, for example by sufficiently formalized reference models or specific adaptation mechanisms. The adaptation is often only supported by imprecise recommendations, for instance in the form of advantages and disadvantages of each alternative solution. In addition to an adequate formalization, there is a lack of a consistent, interconnected and interrelated representation of the individual models and concepts. The individual solutions are often discussed without interdependencies and common interfaces. A large number of articles deal with the procedure and the interdependencies within the production, logistics and factory planning process profoundly and comprehensively. The actual design of the processes is not in focus. Instead, the planning activities and corresponding methods are described. The question is not answered sufficiently, how each planning object has to be designed situationally by using an adaptation mechanism. For example, GUENTHNER [18] developed an adaptive logistics planning process but there is no expand on the actual adaptation mechanism in the process design and the associated planning alternatives.
In summary, the descriptions of procedure models have a higher degree of formalization as the representations of fundamental concepts and methods of production, logistics and factory planning [6].

7 Conclusion and Research Agenda

Respectively to the research questions, the results of the literature review can be summarized as follows.

RQ1: Which reference models are describing the current state of business practice of manufacturing companies in production and logistics planning?

- Identified reference models can be classified by five thematic clusters
- Focus of CIM and digital factory on system and data integration
- Focus of PPC on planning and control of the technical order processing
- Focus of SCM on inter-company process design
- Procedure models with a high degree of formalization
- Focus of the use cases: automobile manufacturer

RQ2: What gaps and potentials for development can be identified in the current reference model portfolio?

- No reference process models for the design of modern production systems
- Possible solutions for process design with a low degree of formalization and without concrete adaptation mechanisms
- Lack of a consistent, interconnected and interrelated representation
- Lack of cross-sector and neutral representation

The literature base confines the validity of the results. Nevertheless, due to the high number of search results the following research agenda can be deduced for reference models in the field of production and logistics planning: The development of a framework for process descriptions of efficient production and logistics processes, which includes sufficiently formalized and adaptive reference process models for the design of modern production systems. Further, the framework is suitable for organizational and operational structure design in SMEs. Therefore also the identification of appropriate adaptive parameters is necessary.

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