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Integrating Production Planning in Collaborative Manufacturing: Systematic Literature Review, and Future Research Direction

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Abstract:

Purpose: This article examines the relevant literature to show how integration between Collaborative Manufacturing and Production Planning can be used and supported in the manufacturing business. This study seeks to provide a complete picture of the present condition, research trend, and application of Collaborative Manufacturing by considering some production planning indicators to assist many companies implementing greater technical collaboration amongst them.

Design/methodology/approach: This analysis set all currently available studies on collaborative manufacturing and production planning through a comprehensive examination of the literature. During the review, a series of measures were taken. The study began by determining the study's objectives, selecting acceptable keywords, and reducing the selected articles based on a various criterion. The final paper which met the review's criteria was subjected to a more thorough examination. A review of literature has been conducted which include 62 primary studies from Academic databases: Scopus and ScienceDirect with main focus on collaborative manufacturing and production planning.

Findings: The study's three primary conclusions are as follows. An overview of the variables influencing collaborative manufacturing and production planning is presented first. The second point is the identification of a number of ideas, techniques, and mathematical modeling in collaborative manufacturing and production planning. Third, Collaborative Manufacturing and Production Planning's future research directions are given.

Research limitations/implications: Likewise, future research may consider numerous goals, the fusion of optimization and metaheuristic techniques, and other tools to enhance the performance of the model's goal. The paper's objectives are to present a brief review of the current situation and to pave the way for further field research.

Practical implications: Collaborative manufacturing must not solitarily concentrate on strategic aspects while managing their networks. Rather, consideration should be given to more technical factors, like production planning. Future academics will use the future research direction provided on this study as a guide to find the method to approach joint production planning.

Originality/value: Additionally, this study provides various areas for future research and serves as a guide to advance studies' research in collaborative manufacturing and production planning.

Keywords: collaborative manufacturing, production planning, systematic literature review.

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1. Introduction

Currently, a corporation may obtain a competitive advantage by collaborating with other companies rather than relying solely on its resources. The idea of a Collaborative Network, which is the foundation for the creation of multiple entities (e.g., companies and individuals) that are independent, geographically scattered, and diversified in terms of the operating environment, culture, social capital, and goals (Camarinha-Matos, 2005). According to Camarinha-Matos, Afsarmanesh, Galeano and Molina (2009) the main difficulty in manufacturing organizations is quick response to market demands by sharing and jointly exploiting competencies and resources. Companies must innovate and discover the most effective method to thrive in a world where global trade is always evolving. The business must be able to produce items which satisfy a better degree of customer satisfaction, at competitive rates, on schedule, and with the highest quality (Firmansyah & Amer, 2013).

Collaborative manufacturing combined with other topics is an interesting topic on today's competitive manufacturing worlds, for example: Decision Support System for Collaborative Manufacturing (Lin, Nagalingam, Kuik & Murata, 2012), Knowledge Loss in Collaborative New Product Development (Shankar, Mittal, Rabinowitz, Baveja & Acharia, 2013), Collaborative Manufacturing and Internet of Thing (Varela, Putnik, Manupati, Rajyalakshmi, Trojanowska & Machado, 2018), Collaborative Human-Robot (Cherubini, Passama, Crosnier, Lasnier & Fraisse, 2016), and Collaborative Supply Chain Management (Triqui-Sari & Hennet, 2016). Meanwhile, production planning is an important process on every manufacturing company. Many researchers have investigated production planning in every stage and several focus on the manufacturing process (Akbar & Irohara, 2018). Some interesting problems in production planning need to be solved. These problems extent all phases of production planning and management, as shown by the extensive study conducted for each phase including aggregate planning (Tuan & Chiadamrong, 2022), forecasting (Chang, Li, Huang & Chen, 2015), lot sizing or material requirement planning (Xu, Liu & Chen, 2017), and scheduling (Akbar & Irohara, 2018).

No.	Author	Focus						Description
		CN	CMN	CM	I.4	SME	PP	
1.	Guzman, Andres & Poler, 2021	-	-	-	-	-	√	Model and Methods for Scheduling, Sequencing, and Production Planning Issues
2.	Firmansyah & Amer, 2013	-	√	-	-	-	-	An Examination of Network Models for Collaborative Manufacturing
3.	Zahoor, Al-Tabbaa, Khan & Wood, 2020	-	-	√	-	√	-	Working Together and Globalizing SMEs: Findings and Suggestions
4.	Varela et al., 2018	-	-	√	√	-	-	Reflections on Collaborative Manufacturing Based on Cloud and I4.0
5.	Proposed review	-	-	√	-	-	√	Reflections on Collaborative Manufacturing and Production Planning

CN: Collaborative Networks, CMN: Collaborative Manufacturing Networks, CM: Collaborative Manufacturing, I4: Industry 4.0, SME: Small and Medium Enterprise, PP: Production Planning

Table 1. Recent Review on Collaborative Manufacturing and Production Planning

As shown in Table 1, so far, several review-based studies have advanced Collaborative Manufacturing Networks research and Production Planning research by concentrating on various review directions. These reviews basically directed under the following five categories. The first reviewed the need of efficient production planning, scheduling and sequencing in several companies and in recent decades (Guzman et al., 2021). Production planning, scheduling, and sequencing issues have been categorized in this article review. Additionally, it has been discovered that several modeling techniques and methodologies are utilized to scheduling, sequencing, and production planning challenges. A literature review on collaborative manufacturing networks was also occupied by Firmansyah and Amer (2013). According to the findings of the literature study, research have been conducted on (1) Improving product cycles, lowering costs, contemporary network cooperation, and developing global strategies. (2) Collaborative manufacturing is a new manufacturing paradigm in which businesses cooperate to fully utilize each other's resources and competencies. (3) Research suggests collaborative manufacturing as a possible solution to a company's limits. Small and medium-sized businesses are allowed to develop from collaboration in a number of methods, such as enhancing the competencies, capacities, and skills of the organization through resource sharing, system integration, the development of more sophisticated goods, gaining market share internationally, and reducing production costs. (4) Other motivations for collaborative manufacturing stated by other academics, include remaining competitive and surviving in the market, being more efficient and wiser on working with suppliers, partners, and consumers, increasing sales, and lowering expenses. (5) Collaboration on project planning and scheduling, product design and development, forecasting, production systems, and supply chain collaboration are all aspects of collaboration manufacturing that have been studied.

The third section examined important works in addition to important factors and moderators affecting SMEs' internationalization (Zahoor et al., 2020). The fourth study examined how the Internet of Things might be utilized for collaborative manufacturing. To make wise assessment and expand the market, a framework for leveraging technology and management must be established. This framework must include big data in interconnected production systems, collaborative and cloud manufacturing processes, and technology for manufacturing (Varela et al., 2018).

Several articles above have reviewed production planning areas (models and methods on production planning, scheduling and sequencing) and collaborative manufacturing networks (CM+IoT, CM+KM, CM+SME). As authors knowledge, there is no scholars reviewing the integration between production planning and collaborative manufacturing yet. In summary, existing studies have increasingly emphasized the coordination and cooperation among Collaborative Manufacturing member enterprises, without offering the production planning for node enterprises participating in collaborative manufacturing. At the same time, the collaborative manufacturing needs to accommodate production planning in their collaboration. Therefore, this paper studied the integration production planning in collaborative manufacturing environment.

This paper's main contribution is to close this discrepancy by looking at scientific articles in several databases to discover the current knowledge in Collaborative Manufacturing, Production Planning, and integration between Collaborative Manufacturing and Production Planning. This article examines the relevant literature to show how Collaborative Manufacturing and Production Planning can be utilized and advantageous in manufacturing. This study seeks to provide a complete picture of the present condition, research trend, and application of Collaborative Manufacturing by considering some production planning applied by many companies on implementing greater technical collaboration amongst them. There are three specific goals from this study. First, it is critical to understand both what requires to be done and what has already been achieved in the field of collaborative manufacturing and production planning. The second goal is to conduct a thorough literature review to determine the factors affecting the collaborative manufacturing and production planning. Third, to suggest a course of research for the future. As a result, this literature analysis aims to identify the frameworks, models, techniques, and research trends that were used in research relating to collaborative manufacturing and production planning from 2013 to 2023.

2. Methodology

2.1. SLR Protocol

To perform reference searches, the Systematic Literature Review (SLR) method was utilized, which corresponds to Kitchenham, Pretorius, Budgen, Brereton, Turner, Niazi et al. (2010). The SLR's initial stage is to develop a procedure for conducting a comprehensive review, which will guide the SLR's actions. Figure 1 illustrates the SLR's systematic steps. Overall, the research methodology aligns with a section of the protocol proposed by Kitchenham et al. (2010).

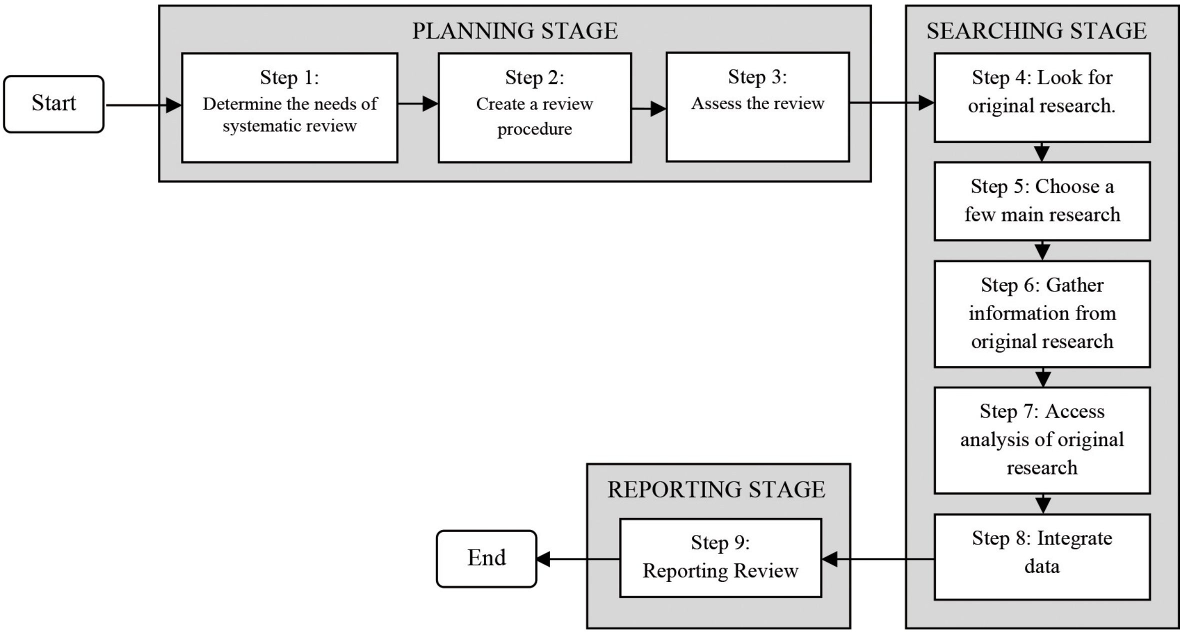

Figure 1. The Protocol of Systematic Literature Review

This protocol review aims to reduce study bias and serve as a crucial component of SLR. This protocol lays forth a step-by-step procedure for selecting literature. This process has various stages, including study identification, question formulation, search methodologies, selection criteria, quality assessment, data extraction, and data synthesis (Kitchenham et al., 2010; Varela et al., 2018).

2.2. Research Question Formulation

Despite many good researchers have researched production planning, only few have particularly examined about collaborative manufacturing. This study will first provide an overview of research conducted on Collaborative Manufacturing and Production Planning from 2013 to 2023 in order to show where those concepts are today. To carry out this matter, it is essential to consider the area of research interest in this field. The consequence was the development of research questions, which included:

RQ1: What are the primary components of the collaborative manufacturing and production planning concepts?

Researchers need to have a better understanding of collaborative manufacturing and production planning and able to distinguish between the findings of each publication.

RQ2: What theories, frameworks, and models are the collaborative manufacturing and production planning idea based on?

Which theories, frameworks, and models have been created by academics and industry professionals whom interested in collaborative manufacturing and production planning?

RQ3: What are the knowledge gaps in current collaborative manufacturing and production planning research and what is the future research direction?

In order to expand researchers' horizons and to identify the areas which require investigation, a deeper understanding of knowledge gaps in the field of collaborative manufacturing and production planning is necessary.

Table 2 shows the keywords used throughout the search.

Keywords 1	Keywords 2
Collaborative networks, collaborative manufacturing	Production planning, production planning tool, and production planning method.

Table 2. List of Keywords

This study combines two sets of keywords to gather relevant sources from the ScienceDirect and Scopus databases. To combine these two categories' keywords, the search equation used was: ("Collaborative Manufacturing" OR "Collaborative Networks") AND ("Production Planning" OR "Collaborative Production Planning").

2.3. Criteria Employed in the Literature Review

Table 3 shows the criteria employed –or not– in the literature review of the compiled publications.

Inclusion Criteria	Exclusion Criteria
• Research for publications between 2013 and 2023 • Research on collaborative production and manufacturing • Paper that has undergone peer review and has been published in English • Only high-quality articles considered on a reputable database, including ScienceDirect, and SCOPUS	• Conduct research in areas unrelated to collaborative manufacturing and production planning • Investigations that are primarily focused on a technical perspective, conversations, or reports rather than scientific research investigations, • Studies that are duplicated • Not the product of a peer-review procedure.

Table 3. Inclusion and Exclusion in the Literature Study

2.4. Reference Search Procedure

To explore articles relevant to this literature study, searches were performed using flowchart as seen in Figure 2.

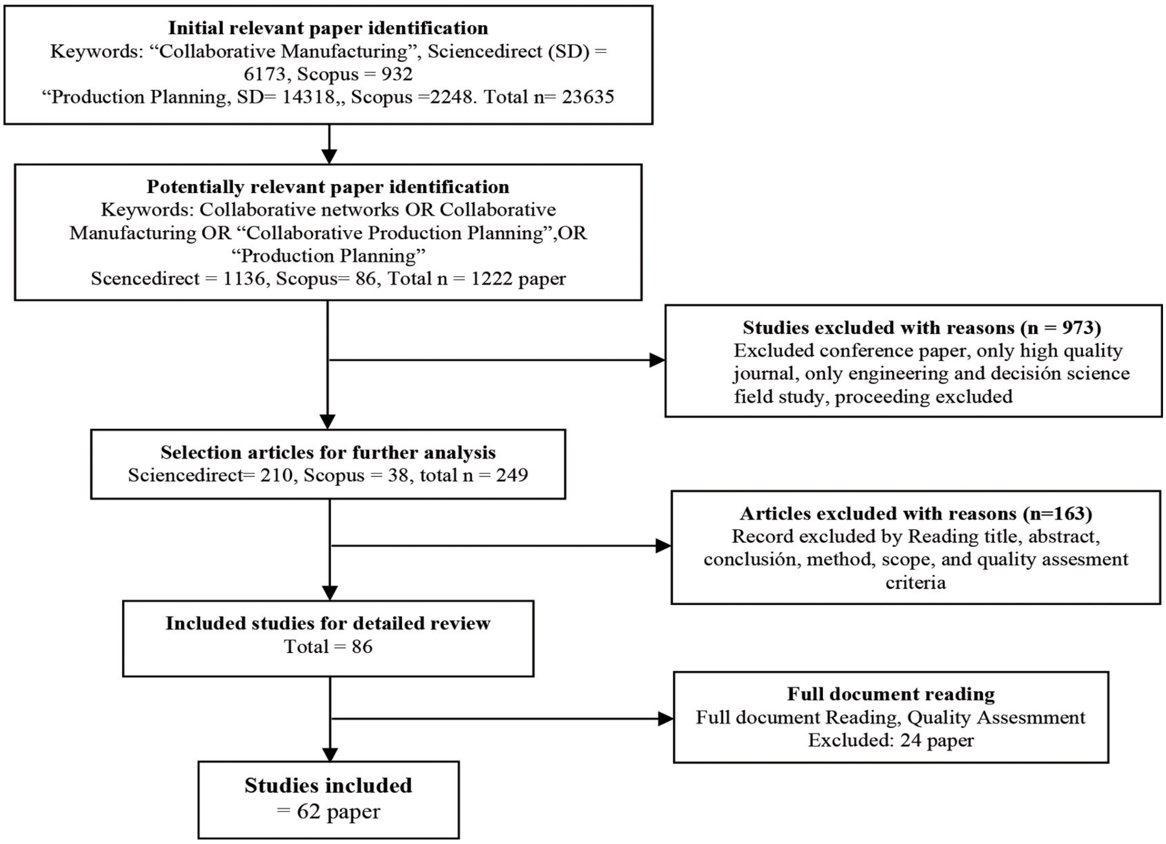

Figure 2. Systematic Literature Review Process

3. Results

As many as 62 journal articles under the specified topic were obtained as the result of a systematic review.

3.1. Descriptive Analysis

3.1.1. Article Number per Year

Determining the year of publication marks the beginning of the bibliographic analysis process. There were 62 journal publications produced during 2013–2023, all of which are of excellent quality and are Scopus-indexed.

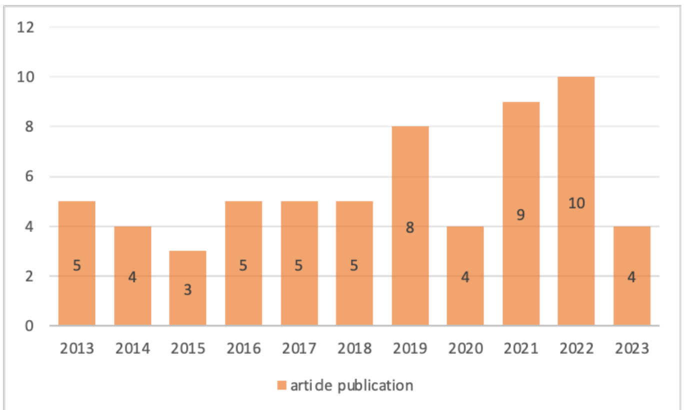

Figure 3. Year of Article Publication

Figure 3 shows the mapping of the year of publication. Five articles were obtained in 2013; four articles were generated in 2014; three articles were generated in 2015 and five articles in 2016; five articles were identified in

2017; five articles were produced in 2018; eight articles were obtained in 2019 and four articles in 2020; nine articles in 2021, ten articles in 2022, and four articles in 2023.

From Figure 3, it is identified that the most quantity of published articles occurred in 2022, which is ten publications. It indicates that many articles were published on the topic of Production Planning and Collaborative Manufacturing in that year.

3.1.2. Articles Publisher Source

The selected papers were originated from ScienceDirect and Scopus publisher sources which can be accessed through several journal databases. The journals name and number articles can be summarized in Figure 4.

From Figure 4 it can be concluded that Computers & Industrial Engineering is the highest number articles discussed about Collaborative Manufacturing and Production Planning with seven articles, Journal of Cleaner Production with five articles, European Journal of Operational Research with four articles, and Advanced Engineering Informatics with four articles.

International Journal of Production Research is the next highest number articles with three articles, and Expert Systems with Applications with also three articles. Robotics and Computers Integrated Manufacturing, International Journal of Information Management, and Computers in Industry consist of two articles.

The remaining journals which are Advances in Industrial and Manufacturing Engineering, Advances in Production Management Systems, Applied Mathematical Modelling, Applied Mathematics and Computation, Business Horizons, Decision Support Systems, Energy & Buildings, Engineering Applications of Artificial Intelligence, Expert Systems with Applications, Intern. Journal of Production Economics, International Journal of Hydrogen Energy, International Journal of Management Reviews, International Journal of Materials, Mechanics and Manufacturing, Journal of Ambient Intelligence and Humanized, Journal of Business Research, Journal of Industrial Engineering International, Journal of Industrial Information Integration, Journal of Intelligent Manufacturing, Journal of Innovation and Knowledge, Journal of Knowledge Management, Journal of Manufacturing Systems, Journal of Systems and Software, Management and Production Engineering Review, Management Decision, Mathematical Problems in Engineering, Omega (United Kingdom), Operations Research Letters, Resources, Conservation and Recycling, Sustainability (Switzerland), Sustainable Materials and Technologies, Technological Forecasting & Social Change Performance has one article.

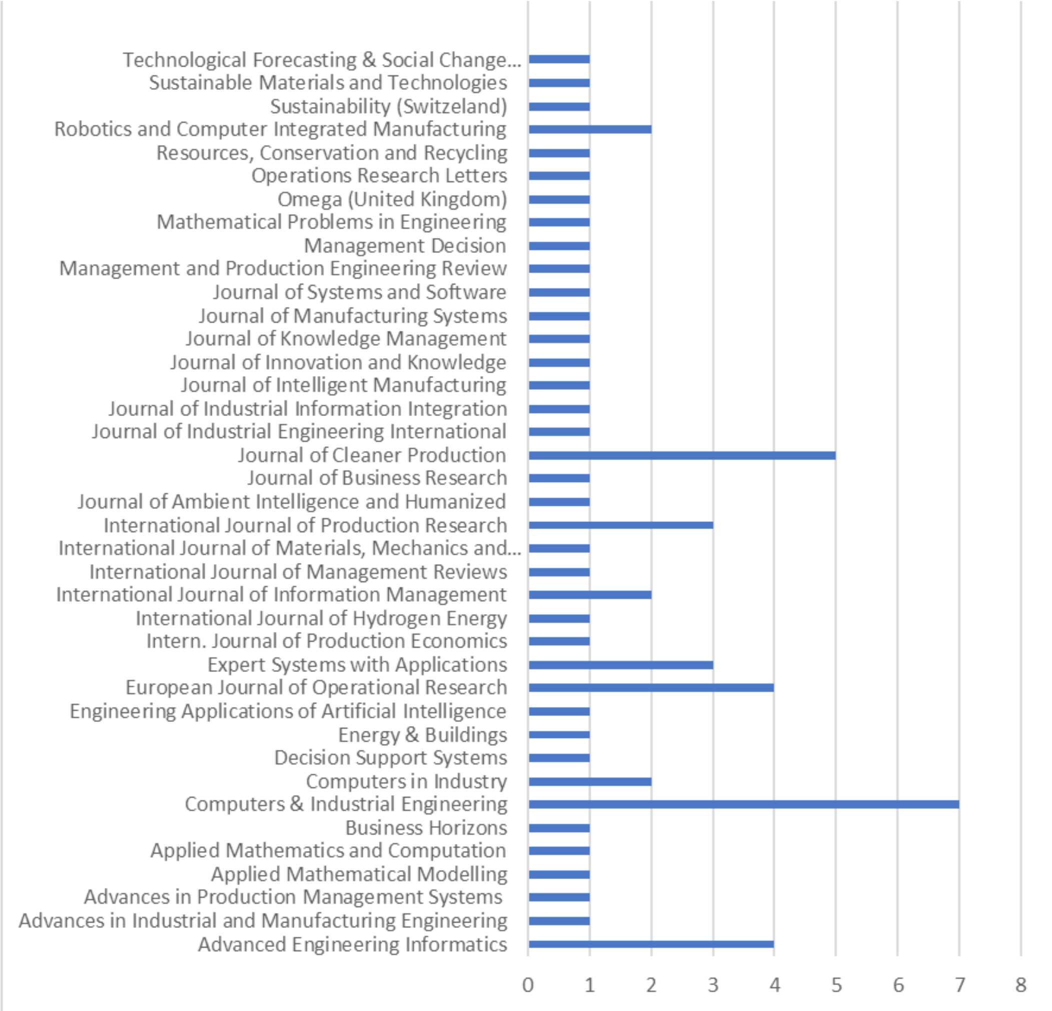

Figure 4. Articles Journal Source

3.2. RQ 1. Current Knowledge on Collaborative Manufacturing and Production Planning

3.2.1. Focus and Content Analysis

Recent research on Production Planning, Collaborative Manufacturing, and the combination of Production Planning in Collaborative Manufacturing can be grouped using intersection diagrams as shown in Figure 5 below.

Collaborative Manufacturing can be divided into sub topics CM and KM, CM and SME, CM and IoT, CM and NPD, C Human Robot, CSCM, and CM and DSS. As for Production Planning can be grouped into Aggregate Planning, Lot Sizing, Scheduling, Forecasting, and Worker Assignment.

There is one reference which examines the integration of CM with PP, specifically Pan, Zhang and Cao (2014) and Cheng, Bi, Tao and Ji (2020). The topic of Knowledge Management in Collaborative Manufacturing has attracted the attention of researchers, including CM and SME, CM and IoT, CM and NPD, C Human Robot, and CM and DSS. The topic which has attracted the most attention is Collaborative Supply Chain Management (n= 6 articles).

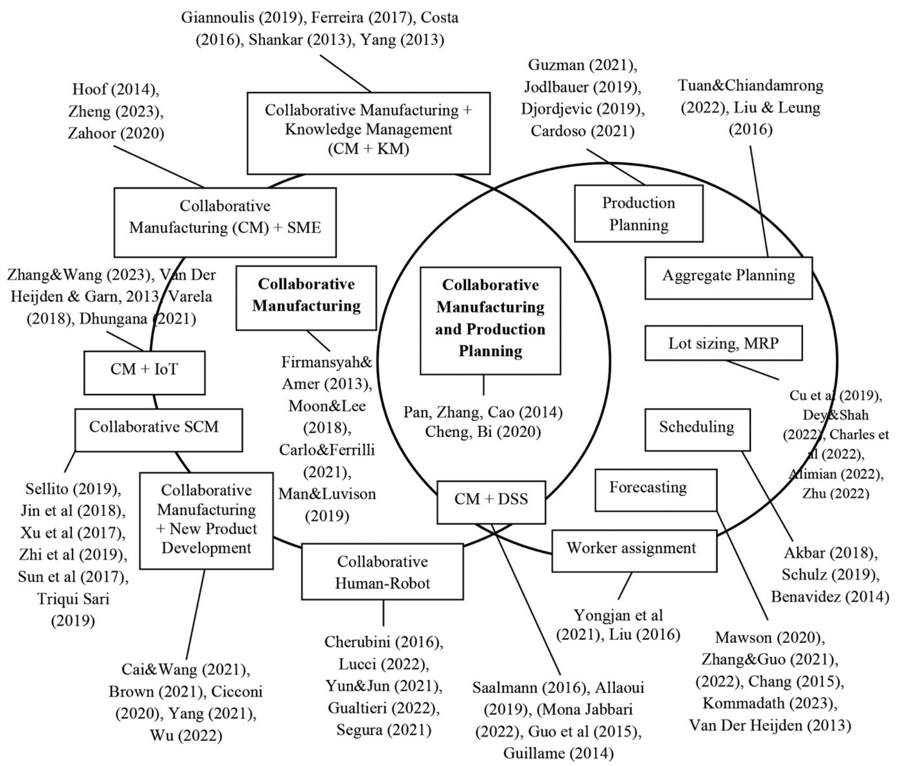

Figure 5. Combination existing knowledge in Collaborative Manufacturing and Production Planning
(DSS: Decision Support System, IOT: Internet Of Thing, CSCM: Collaborative Supply Chain Management)

3.2.2. Literature Classification and Coding

Literature review classification can be illustrated in Figure 6.

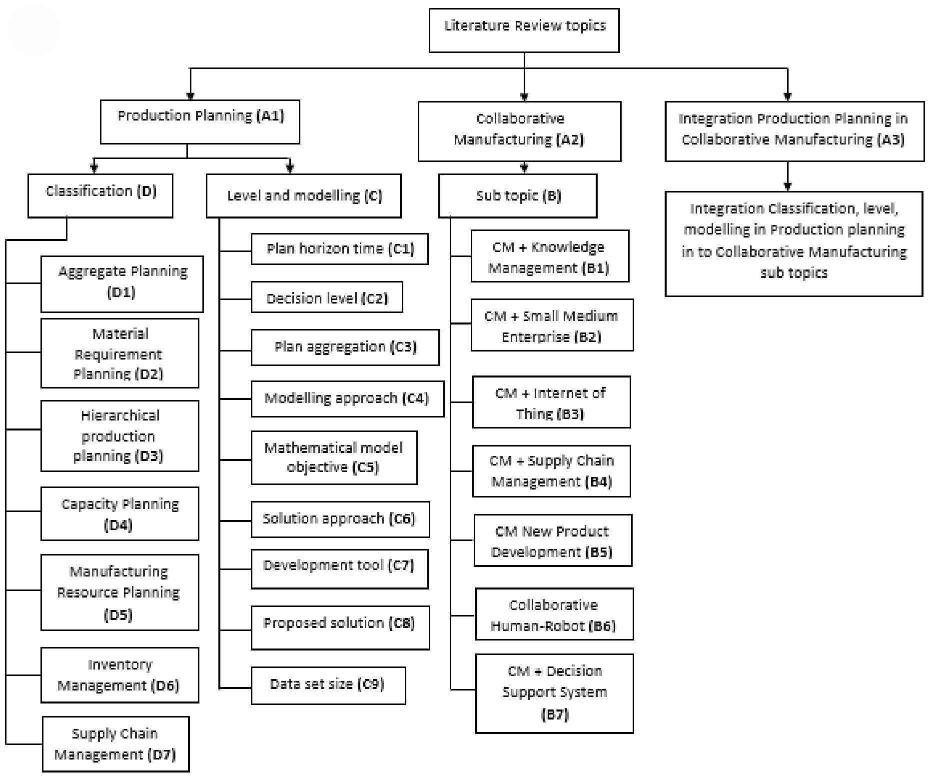

Figure 6. Literature Review Classification and Coding

Literature Review can be divided into three main topics: Production Planning (A1), Collaborative Manufacturing (A2), and Integration Production Planning in Collaborative Manufacturing (A3). In recent decades, several researchers have become interested in effective production planning, scheduling, and sequencing requirements. The dynamic nature of consumer demands causes a challenge to manufacturing, since companies are required to produce with less resources while maintaining product quality and promptly completing customer expectations (Guzman et al., 2021). Classifying research in production planning subjects into Aggregate Planning (D1), Material Requirement planning (D2), Hierarchical Production planning (D3), Capacity planning (D4), Manufacturing Resource planning (D5), Inventory Management (D6), and Supply Chain planning (D7). Guzman et al. (2021) conducted a thorough framework encompassing the degrees of plan aggregation and disaggregation, modeling strategies to represent various plan and level of research output were used to assess the current status of such research. This review was completed on Models and Algorithms for Production Planning. Production planning has been promoted as a successful method that provides flexibility in handling ambiguous information ever since the demand for products is unpredictable. Production planning problems, according to Guzman et al. (2021) can be categorized based on plan horizon time (C1), decision level (C2), plan aggregation (C3), modelling approach (C4), mathematical model objective (C5), solution approach (C6), development tool C7), proposed solution (C8), and set size (C9). Conventional production planning problems result in a production schedule that minimizes costs by considering setup, production, and inventory holding costs. The most recent research add a number of characteristics that were discovered in manufacturing businesses' actual problems to this traditional planning.

Choosing the appropriate levels of labor, capacity, holding inventory, subcontracting, back-ordering or lost sales, and even pricing to meet market demand while minimizing total costs or maximizing total profit over a predetermined time horizon is done through the medium –to long– term capacity planning process known as aggregate planning (from six to twelve, or even eighteen months) (Tuan & Chiadamrong, 2022). Aggregate planning comply with corporate goals and guidelines. Forecasting demand with various parameters, including regular time, overtime, hiring, downsizing, inventory, subcontracting, etc., serve as the input for aggregate planning. The whole planning process has to consider several restrictions and production resources. Aggregate planning's output will result in decision-making factors, including regular time production, overtime production, subcontracting, inventory, and workforce levels (hiring and shrinking) in each period (Tuan & Chiadamrong, 2022). Aggregate Planning in the several papers is combining with other concept such as Cellular Manufacturing System (CMS) (Kwon, Schoenherr, Kim & Lee, 2021; Liu, Wang & Leung, 2016).

Collaborative manufacturing might be implied as an extension of the Cellular Manufacturing System (CMS) idea. If manufacturing collaboration is at the inter-company level, then CMS is at the level of manufacturing cell cooperation. It would be fascinating to apply CMS research to a collaborative manufacturing setting. More complex factors, such as capacity planning, setup costs, reconfiguration expenses, and alternative processing times, are considered in recent CMS research. Numerous researches on the most recent CMS regard a number of novel elements, including scheduling, worker flexibility, machine malfunction, production planning, and worker assignment (Chu, Gao, Cheng, Wu, Chen, Shi et al., 2019).

To determine how many goods will be processed by a machining resource, a manufacturing organization must solve the lot-sizing problem on the shop floor. Koch, Arbaoui, Ouazene, Yalaoui, De Brunier, Jaunet et al. (2022) offers a challenge for integrated lot size and scheduling that was motivated by a practical use in the off-road tire business. Within a limited planning horizon, this challenge considered allocating different goods on many computers in parallel with intricate eligibility conditions. Dey & Shah (2022) proposed lower bound on size of branch-and-bound trees for solving lot-sizing problems. (Charles, Dauzère-Pérès, Kedad-Sidhoum & Mazhoud, 2022) solved the allowed multi-item lot-sizing problem with setup costs and times on a rolling horizon. A fresh combined lot-sizing and price issue for many products with backlogs and constrained production capability also compelling to be studied (Alimian, Ghezavati, Tavakkoli-Moghaddam & Ramezanian, 2022). Mixed-Integer Non-Linear Programming (MINLP) was used to study the parallel-line Capacitated Lot-Sizing Problem (CLSP) with the sequence-dependent setup time/cost, due date, and preventive maintenance planning. The optimum sequence, beginning time, and completion time of the lots, together with the best preventive maintenance plan, are the decision factors of these models. A medium-term production planning called Material Requirements Planning

(MRP) attempts to plan the master production schedule's end-item needs over a limited planning horizon. Zhu, Zhang, Ding, Chan, Hui and Zhang (2022) suggested a Hybrid Chance-Constrained Programming (HCCP) model that satisfies both fuzzy capacity constraints and stochastic needs to estimate the lot sizes of all products. Akbar and Irohara (2018) conducted a detailed investigation, considering more sustainable elements of the state and evolution of sustainable scheduling. Research on Energy-Aware Scheduling (EAS) was conducted by (Schulz, Neufeld & Buscher, 2019). Guzman et al. (2021) studied and reviewed concepts and techniques for production scheduling, planning, and sequencing. The scheduling issue may be solved using many alternative models and techniques, all varying degrees of solution quality. Flow shop scheduling –a specific case in scheduling, has been studied by Benavides, Ritt and Miralles, (2014). This paper addresses the problem by considering several elements, such as worker assignment, and proposing a heuristic research based on path relinking and scatter search.

Manufacturing businesses face unpredictable demand, compelling forecasting for future demand to keep production operating smoothly. Controlling the early phases of a production system efficiently is a critical challenge for businesses (Chang et al., 2015). The forecasting approach has lately drawn several researchers to explore it. Mawson and Hughes (2020) suggest a prediction model that uses a neural network to anticipate energy usage in manufacturing based on production schedules. Van Der Heijden and Garn (2013) use a multivariate analysis and Kernel Density technique to forecast the profitability of the automobile industry. Chang et al. (2015) suggested forecasting technique employing several Gray techniques and tiny industrial data sets.

Firmansyah and Amer (2013) reviewed Collaborative Manufacturing Networks. Collaborative manufacturing was one way to deal with their limits. By pooling resources and becoming providers of entire systems, learning and sharing crucial knowledge, creating more complicated goods, expanding their companies' worldwide market share, and cutting production costs, Collaborating Companies may improve their companies' skills, capacities, and capabilities. When it comes to resource limitations, inadequate management, a lack of new product development for company continuity, and a lack of industry networking and cooperation, SMEs faced many more challenges than huge companies (Zheng, Du, Sun, Eynard, Zhang, Li et al., 2023).

Production Planning also an interesting topic that can be integrated with Collaborative Manufacturing. Pan et al. (2014) suggested a mathematical model for make-to-order manufacturing collaborative production planning with production time windows and order splitting. The issue takes manufacturing capacity and time windows into account. Cheng et al. (2020) proposed hypernetwork-based models algorithm for scheduling problem in distributed manufacturing. The illustrating problem studied by Pan et al. (2014) discussed clients putting orders with a company that can fulfill them at several different production sites. Research on integrating Collaborative Manufacturing and Production Planning is scarce. Therefore, this integrating topic between CM and PP is open to be explored in future research. Based on classification that proposed by (Guzman et al., 2021) the authors categorized the reviewed study on the decision level shown in Table 4.

3.2.3. Research Focus and Decision Level

Research focus and decision level described in Table 4 as follow.

In general, decision levels within a company can be grouped into three categories: Strategic, Operational, and Tactical and Operational. Strategic planning is related to the vision of a company. An example of strategic categories on the topic of production planning: Production planning issues on a tactical and operational level might use aggregated or disaggregated data to cover short-term or long-term planning goals.

The two distinct forms of plans in the production planning area are aggregate plans and master plans. Product families, or sets of items belonging to the same category and having comparable configurations, are used in aggregated plans (Guzman et al., 2021). Rather than being an overall plan, production plans can be divided into more detailed programs that specify the product quantities to be produced across time periods typically weekly or monthly. 31,15% of the selected articles addressed the production planning issues, with the majority of those articles dealing with operational level production planning. Decision-making at the operational level is typically attached to selecting a manufacturing facility to create a product. Discussion about the shop floor often refers to scheduling and sequencing strategies. A schedule plan determines how many products must be produced in each period by allocating resources efficiently considering a set of deadlines, release dates, product demand, and operational restrictions. As indicated by the schedule plan, time-tabling activities is the process of allocating times (Akbar & Irohara, 2018). In multi-sites stochastic order planning problems, delivery time and environmental aspect need to be considered. A multi objective mathematical model is developed to minimize the total delay and the excessive carbon emissions in textile manufacturing supply chains (Zhang et al., 2021).

Research Focus	Decision level	Amount of Articles	Reference
Collaborative Manufacturing (A2)	Strategic	6	Firmansyah & Amer, 2013; Moon, Lee, Park, Kiritsis & von Cieminski, 2018; Carlo, Ferilli & Buscema, 2021; Man & Luvison, 2019; Graça & Camarinha-Matos, 2017
	Operational	-	-
	Tactical and Operational	-	-
Production Planning (A1)	Strategic	1	Cardoso, Mesquita, Almeida & Giannetti, 2021
	Operational	18	Kwon et al., 2021; Mawson & Hughes, 2020; Zhang, Guo, Wei, Guo & Gao, 2021; Chang et al., 2015; Kommadath, Maharana & Kotecha, 2023; Chu et al., 2019; Tuan & Chiadamrong, 2022; Liu et al., 2016; Dey & Shah, 2022; Charles et al., 2022; Alimian et al., 2022; Zhu et al., 2022; Schulz et al., 2019; Benavides et al., 2014; Chang et al., 2015; Van Der Heijden & Garn, 2013; Jodlbauer & Strasser, 2019; Djordjevic, Petrovic & Stojic, 2019
	Tactical and Operational	2	Guzman et al., 2021; Akbar & Irohara, 2018
CM and Knowledge Management (B1)	Strategic	5	Giannoulis, Kondylakis & Marakakis, 2019; Ferreira, Faria, Azevedo & Luisa, 2017; Costa, Soares & De Sousa, 2016; Shankar et al., 2013; Yang, 2013
	Operational	-	-
	Tactical and Operational	-	-
CM and SME (B2)	Strategic	3	Van Hoof, 2014; Zahoor et al., 2020; Zheng et al., 2023
	Operational	-	-
	Tactical and Operational	-	-
CM and IOT (B3)	Strategic	3	Zhang, Wang, Zhou, Chang, Ma, Jing, 2023; Van Der Heiden& Gao, 2013; Varela, 2018; Dhungana, Haselböck, Meixner, Schall, Schmid, Trabesinger et al., 2021
	Operational	-	-
	Tactical and Operational	-	-
CSCM (B4)	Strategic	6	Sellitto, Hermann, Blezs & Barbosa-Póvoa, 2019; Jin, Zhang & Luo, 2018; Wu, Nie & Xu, 2017; Zhi, Liu, Chen & Jia, 2019; Sun, He, Wang, Zhang & Lv, 2017; Triqui-Sari & Hennet, 2016
	Operational	-	-
	Tactical and Operational	-	-
CM and NPD (B5)	Strategic	4	Cai & Wang, 2021; Brown, Baldassarre, Konietzko, Bocken & Balkenende, 2021; Cicconi, 2020; Wu, Zhou, Zheng, Sun & Zhang, 2022
	Operational	1	Yang, Li,& Jiang, 2021
	Tactical and Operational	-	-
	Strategic	-	-

Research Focus	Decision level	Amount of Articles	Reference
C Human-Robot (B6)	Operational	5	Cherubini et al., 2016; Lucci, Monguzzi, Zanchettin & Rocco, 2022; Yun & Jun, 2022; Gualtieri, Rauch & Vidoni, 2022; Segura, Lobato-Calleros, Ramírez-Serrano & Soria, 2021
	Tactical and Operational	-	-
CM and DSS (B7)	Strategic	1	Jabbari, Sheikh, Rabiee & Oztekin, 2022
	Operational	2	Guo, Ngai, Yang & Liang, 2015; Guillaume, Marques, Thierry & Dubois, 2014
	Tactical and Operational	2	Saalmann, Wagner &Hellingrath, 2016; Allaoui, Guo & Sarkis, 2019
CM and Production Planning (A3)	Strategic	-	-
	Operational	2	Pan et al., 2014; Cheng et al., 2020
	Tactical and Operational	-	-
Total amount of articles		**62**	

Table 4. Research Focus and Decision Level of the Reviewed Works

Knowledge Management in Collaborative Manufacturing attracts the attention of researchers. Knowledge Management are discussed in collaborative network structure within the organization to reduce knowledge los and SME Owner-Managers' readiness to exchange information online in rural local business networks (Shankar et al., 2013). Carr, Parker, Castleman and Mason (2013) conducted a poll by persuading owner-managers of the financial advantages of e-commerce and making sure networking events are suitable for them, network coordinators may promote online information exchange.

Zheng et al. (2023) and Zahoor et al. (2020)'s articles on CM and SME focused on the role of CM in SME at the strategic level. No research on this topic examines the position of CMs and SMEs at the operational level. In CM and IoT, systems for Production Planning and Controlling (PPC) are linked to other business divisions in industrial settings (Zarte, Pechmann & Nunes, 2021). Additional data and information possibly assembled and analyzed using Internet-of-Things technology which is considerably easier and swifter than in previous decades to support the production scheduler's decision-making processes. CSCM research topics have attracted the attention of many researchers, including Intelligent Maintenance Systems (IMS) based on machine condition monitoring supplied information for the coordination of a CSCM at the tactical level (Saalmann et al., 2016). CM and NPD also tempt researches by many researchers, for example, Collaborative Circular Proposal Design Tool (Brown et al., 2021), Collaborative Eco-Design Approach Overcome Traditional Limits in NPD (Cicconi, 2020), Collaborative Design Technique for Multiple Types of Graphite End Plate Geometric Parameters (Yang et al., 2021), and Multidisciplinary Collaborative Design with a Digital Twin (Wu et al., 2022). All research related to the Collaborative Human Robot topic is included in the operational category. There are several article studies cooperative human-robot manufacturing cell for homokinetic joint assembly (Cherubini et al., 2016), Cognitive Ergonomics in the Design of Collaborative Assembly Systems between Humans and Robots (Gualtieri et al., 2022).

Saalmann et al. (2016) and Jabbari et al. (2022) discussed Collaborative Manufacturing and Decision Support System in strategic level. According to Saalmann et al. (2016), decision support is crucial for the coordination of an IMS-based intelligent maintenance system, which provides information on machine status monitoring. Jabbari et al., (2022) conducted automatic clustering to assist the decision-maker who lacks knowledge about the characteristics of the dataset and the relevant criteria. Collaborative manufacturing and decision support systems were covered at the tactical and operational levels by Allaoui, Guo and Sarkis (2019). For the purpose of developing a sustainable supply chain, a collaborative decision-making framework was developed.

3.3 RQ2. Theories, Frameworks, and Models which Collaborative Manufacturing and Production Planning Idea is Based On

3.3.1. Articles Categorized as Non-Mathematical Model

Articles about non-mathematical model can be described in Table 5.

No	Special Topic	Author	Method				Important Key Concept	Industry
			Conceptual	Framework	Review	Case studies		
1	Collaborative Manufacturing	Moon et al., 2018	√	-	-	-	Data Driven, Intelligent Collaborative, Production Management	Various
2	Production Planning	Jodlbauer & Strasser, 2019	-	√	-	-	Capacity driven production planning	Manufacturing
3	Production planning	Guzman et al., 2021			√		Production planning level, horizon time	Many
4	Collaborative Supply Chain Management	Saalmann et al., 2016	√	-	-	-	FRISCO assessment approach, concept for Spare Part SC	Spare part industries
5	Collaborative Manufacturing	Carlo et al., 2021	-	-	-	√	Artificial intelligence, to support tourism strategy	Urban destination
6	Knowledge framework for Production Planning	Zarte, Pechmann & Nunes, 2022	-	√	-	-	Combine digitalization (RAMI4.0) and knowledge management	Many
7	CM + IOT (Cloud Manufacturing)	Dhungana et al., 2021	-	√	-	-	Dynamic production planning, set of production, factory capabilities	Many
8	Collaborative Manufacturing Networks	Firmansyah & Amer, 2013	-	-	√	-	Coordination on design and manufacturing activities	Many
9	Collaboration and SME	Zahoor et al., 2020	-	-	√	-	Organizational outcomes, internationalization out- comes, and performance outcomes	Many
10	Collaborative Manufacturing and I4.0	Varela et al., 2018	-	-	√	-	Institutions and physical resources, firm size and firm ownership	Many
11	Collaborative NPD	Cai & Wang, 2021	√	-	-	-	Effort, Revenue, and Cost Sharing Mechanisms	Many
12	Collaborative NPD	Brown et al., 2021	√	-	-	-	Instrument to find partners and determine perceived worth as soon as possible.	Many
13	Collaborative NPD	Cicconi, 2020	-	√	-	-	The interaction in the field of collaboration between several stakeholders	Various
14	Collaborative NPD	Wu et al., 2022	-	-	-	√	Multidisciplinary in collaborative knowledge, modeling, and simulation	Automated cutting machine
15	Collaborative NPD	Yang et al., 2021	√	-	-	-	Implemented following the design of experiment	Fuel cell company

No	Special Topic	Author	Method: Conceptual	Method: Framework	Method: Review	Method: Case studies	Important Key Concept	Industry
16	CM + KM	Giannoulis et al., 2019	-	√	-	-	Design and development an intelligent system to supports a collaboration of experts in health domain	Health
17	CM + KM	Ferreira et al., 2017	-	-	-	√	Knowledge on driver impact to energy consumption	Various
18	CM + KM	Costa et al., 2016	-	-	√	-	Information management process, knowledge management process on internationalisation of SMEs process	Many
19	CM + KM	Shankar et al., 2013	-	√	-	-	Minimise knowledge loss in new product development	Automotive industry
20	CM + KM	Yang, 2013	√	-	-	-	Knowledge transfer between two or more organization	Many
21	C-Human Robot	Cherubini et al., 2016	-	-	-	√	Human–robot interaction, Reactive and sensor-based control	Robotic manufacturing
22	C-Human Robot	Lucci et al., 2022	-	-	-	√	General library of atomic Predicates t	Robotic manufacturing
23	C-Human Robot	Yun & Jun, 2022	-	√	-	-	Utilizing virtual reality in robotic assembly	Robotic manufacturing
24	C-Human Robot	Gualtieri et al., 2022	-	√	-	-	Using cognitive ergonomics in cooperative human-robot	Assembly system
25	C-Human Robot	Segura et al., 2021	-	-	√	-	Robotics Characterization in an Assembly System	Assembly system
26	CM-SME	Van Hoof, 2014	-	-	-	√	Enhancing the ability to absorb information, organizing solutions, and inspiring action	Many
27	CM-SME	Zheng et al., 2023	-	-	-	√	Multi agent collaborative manufacturing in SME	Many
28	CM-IOT	Zhang, Wang, Yang & Gen, 2019	-	√	-	-	Information support technologies for networked manufacturing	Original equipment manufacturer
29	Collaborative Network	Graça & Camarinha-Matos, 2017	√	-	-	-	Matching the requirements to the current outcomes from the field of collaborative networks	Various
30	Production planning	Cardoso et al., 2021	-	-	√	-	Production planning in sustainable industries	Various
31	CM + DSS	Allaoui et al., 2019	-	√	-	-	Sustainability of provided goods by facilitating the formation of multi-party collaborative partnerships throughout a network	Many
32	CSCM	Sellitto et al., 2019	√	-	-	-	Green supply chain management	Various
33	CM + KM	Lin, Wu & Yen, 2012	-	√	-	-	Barrier in Knowledge management	Various
34	CM + DSS	Saalmann et al., 2016	-	√	-	-	Collaborative DSS	Spare part industries
35	CM + KM	Durst & Edvardsson, 2012	-	-	√	-	Knowledge management in SME	Various

Table 5. Overview selected articles: Articles Categorized as Non-Mathematical Model

There are several special topics, such as Collaborative Manufacturing, Collaborative Supply Chain Management, Collaborative Manufacturing + Internet of Thing, Collaborative Manufacturing + Knowledge Management, Collaborative Human-Robot, Collaborative Manufacturing + Small Medium Enterprises, and Collaborative Manufacturing + Decision Support System. Each special topic classifies the method, important key concept, and the industry applied. Articles which categorized as non-mathematical models are presented on Table 5 above. There are references which included into the category of paper reviews, surveys, case studies, frameworks. The most frequent reference in this study is framework categories (n=12). In example, a framework is an approach to manage a certain topic such as Cloud Manufacturing (Dhungana et al., 2021), knowledge management in CM (Zarte, Pechmann & Nunes, 2022), Capacitated production planning (Jodlbauer & Strasser, 2019). Regarding the industry used on each paper, it can be categorized into various industries, many industries, and single industries (case studies). Case studies are frequently utilized to produce insights into several management disciplines. Since case studies involve the application of the concepts presented or from existing concepts, they have benefits over articles that are included in the conceptual model category. Despite their benefits, the researchers in the chosen publications rarely employed case studies (n = 7). The selected articles can also be classified based on important key concept, and the industry taken on those articles. The key concepts are varied in example data driven (Moon et al., 2018), capacity driven (Jodlbauer & Strasser, 2019), production level and horizon time (Guzman et al., 2021), while organizational outcomes, international outcomes, and performance outcomes are also important (Zahoor et al., 2020), and Institutions and physical resources, company size and company ownership are crucial in Collaborative Manufacturing + IoT, etc. The industry taken on the articles can be classified as single industry/case studies, many and various industries. The most articles are categorized as many n=13. Paper classified as single industry, including simple manufacturing case study, spare part industries, urban destination, automated cutting machine, fuel cell company, health, automotive industry, robotic manufacturing, assembly system, and Original Equipment Manufacturer (OEM).

3.3.2. Selected Articles Categorized as Mathematical Model

Selected articles categorized as mathematical model can be found in Table 6.

The literature discusses several domain/sub domain, models and methods for solving production planning (Liu et al., 2016; Dey & Shah, 2022; Liu, Liang & Xian, 2022; Alimian et al., 2022; Zhu et al., 2022; Schulz et al., 2019; Benavides et al., 2014; Chang et al., 2015) Collaborative Manufacturing, and Integrating CM and Production Planning (Pan et al., 2014). The literature discusses several domain/sub domain, models and methods for solving production planning (Liu et al., 2016; Dey & Shah, 2022; Charles et al., 2022; Alimian et al., 2022; Zhu et al., 2022; Schulz et al., 2019; Benavides et al., 2014; Kommadath et al., 2023; Chang et al., 2015; Van Der Heijden & Garn, 2013), Collaborative Manufacturing, and integrating CM and Production Planning (Pan et al., 2014).

One issue Collaborative Manufacturing which requires to be addressed is lowering costs in factories which collaborate with one another (Zhang, Zhao & Sutherland, 2015). In order to achieve a low overall cost, manufacturing scheduling for cooperative enterprises is crucial.

Apart from the total energy cost, there are other studies that discuss Collaborative Manufacturing operations (Sadic et al., 2018). On that research, the production reliability and order priority indicators in a multi-objective model with cost reduction were combined. It was intended to save costs and give higher priority orders to more dependable manufacturers. Hyper-network is a new proposal on the topic of Collaborative Manufacturing (Cheng et al., 2020). Dynamic manufacturing network, a hyper-network model, in distributed and collaborative manufacturing operations was proposed to support distributed and Collaborative Manufacturing operations.

Supply Chain Network Design (SCND) is a crucial component of acceptable performance measurements in Collaborative SCM (CSCM), which compares the effectiveness and/or efficiency of the present system to other systems (Dehdari-Ebrahimi & Momeni-Tabar, 2017). Green Supply Chain Network is proposed and it would incorporate existing supply chain management practices into long-term supplier relationships and organizational purchasing choices. A distributed method was developed to facilitate coordination between collaborating agents from the remote production locations to the central coordinator. When a business has a lot of truck resources, it needs certain management techniques (Chargui et al., 2019). Energy usage and truck scheduling are decision variables to be assessed in this investigation. Triqui-Sari and Hennet (2016) successfully overcame a two-stage inventory planning issue. The research brought up an inventory planning concern in the upstream section of the network, which consists of the central warehouse and the three distribution locations.

		Domain/ Sub domain					Objective Category			Modeling Approach				Algorithm				
No	Author	CM	CSCM	PP	CNPD	CM+PP	ECO	ENVI	SOCIO	MIP	ILP	DP	else	GA	ANN	PSO	else	Industry
1	Guo, Wong, Li & Ren, 2013		-	√	-	-	√	√	-	√	-	-	PO	√	-	-	NSGA	-
2	Sadic, Pinho, Sousa & Antonio, 2018	√	-	-	-	-	√	-	√	√	-	-	Fuzzy TOPSIS	-	-	-		-
3	Cheng et al., 2020	-	-	-	-	-	√	-	-	√	-	-	GC	-	-	-	BC	-
4	Dehdari-Ebrahimi & Momeni-Tabar, 2017	-	√	-	-	-	√	-	-	√	-	-	-	-	-	-	-	Electricity factories
5	Djordjevic et al., 2019	-	-	√	-	-	√	-	-	-	-	-	FLP	-	-	-	-	Automotive industry
6	Chargui, Bekrar, Reghioui & Trentesaux, 2019	-	√	-	-	-	√	√	-	-	-	-	-	-	-	-	-	Docking terminal
7	Triqui-Sari & Hennet, 2016	-	√	-	-	-	√	-	-	-	-	-	SP	√	-	-	-	Retail distribution network
8	Kwon, Schoenherr, Kim & Lee, 2018	-	-	√	-	-	√	-	-	√	-	-	-	-	-	-	-	-
9	Jabbari et al., 2022	-	-	√	-	-	√	-	√	-	-	-	DEA	-	-	-	EA	-
10	Gong, Kao & Peters, 2019	-	-	√	-	-	√	√	-	√	-	-	-	-	-	-	-	Biophramaceu-tical industry
11	Du & Guo, 2016	-	-	√	-	-	-	-	√	√	-	-	-	-	-	-	AC	-
12	Guo et al., 2013	-	-	√	-	-	-	-	√	√	-	-	MOP	-	-	-	-	Smart factories
13	Chang et al., 2015	-	-	√	-	-	-	√	-	-	-	-	GFM	-	-	-	-	-
14	Liu, Wang & Leung, 2016	-	-	√	-	-	√	-	-	√	-	-	-	-	-	-	HBFA	Fiber connector company
15	Charles et al., 2022	-	-	√	-	-	√	-	-	-	-	-	MINLP		-	-	-	-
16	Dey & Shah, 2022	-	-	√	-	-	√	-	-	-	-	-	-	-	-	-	B&B	-
17	Alimian et al., 2022	-	-	√	-	-	√	-	-	-	-	-	MINLP	-	-	-	-	-
18	Zhu et al., 2022	-	-	√	-	-	√	-	-	-	-	-	HCCP	-	-	-	-	-
19	Schulz, 2019	-	-	√	-	-	√	-	-	-	-	-	IMOP	-	-	-	ILS	-
20	Benavidez, 2014	-	-	√	-	-	√	-	-	√	-	-	-	-	-	-	-	-
21	Zhang et al., 2021	-	-	√	-	-	√	-	-	-	-	-	MESO	-	-	-	EA	Textile manufacturing

No	Author	Domain/ Sub domain					Objective Category			Modeling Approach				Algorithm				Industry
		CM	CSCM	PP	CNPD	CM+PP	ECO	ENVI	SOCIO	MIP	ILP	DP	else	GA	ANN	PSO	else	
22	Chang et al., 2015	-	-	√	-	-	√	-	-	√	-	-	GM	-	-	-	-	-
23	Kommadath et al., 2023	-	-	√	-	-	√	-	-	√	-	-	MINLP	-	-	-	COA	Petrochemical industries
24	Van Der Heijden & Garn, 2013	-	-	√	-	-	√	-	-	√	-	-	MVS	-	-	-	-	-
25	Wang n Yeh, 2014	-	-	√	-	-	√	-	-	-	√	-	-	-	-	√	-	Garden equipment manufacturers
26	Pan et al., 2014	-	-	-	-	√	√	-	-	√	-	-	-	-	-	√	-	Iron and steel
27	Cheng et al., 2020	-	-	-	-	√	√	-	-	√	-	-	-	-	-	-	-	-

CM: Collaborative Manufacturing, DP: Dynamic Programming, MILP: Mixed Integer Linear Programming, ILP: Integer Linear Programming, else: PO: Pareto Optimization, MOP: Multi Objective Programming, LoSP: Stochastic Programming, MINLP: Mixed Integer Non-Linear Programming, HCCP: Hybrid Chance Constrained Programming, Fuzzy TOPSIS, MESO: Multi Evolutionary Stochastic Optimization, GM: Grey Model, MVS: Multivariate Statistic. GA: Genetic Algorithm, PSO: Particle Swarm Optimization, ANN: Artificial Neural Networks, else: BC: Bee Colony, AC: Ant Colony, hybrid bacteria foraging algorithm (HBFA), B&B= Branch and Bound, ILS: Iterated Local Search, EA: Evolution Algorithm, COA: Coyote Optimization Algorithm, NSGA.

Table 6. Overview of Selected Articles: Articles Categorized as Mathematical Model

Troubleshooting production planning conflict resolution, allocating conflict resolution (CRP) benefits among group members in group creation is one aspect studied by Gong, Kao and Peters (2019). Scheduling in production attracted by researchers to study. A planned structure is required when a corporation has several production divisions, plants, and production processes. Creating a multi-objective order scheduling issue model in production planning is one way to overcome this (Du & Guo, 2016). In early production planning, forecasting is important to predict demand. For small data set, Grey Forecasting Model was proposed to forecast the incoming demand (Chang et al., 2015). Whilst, Aggregate Production Planning (APP) is needed to make product manufacturing plans at the company level (Wang & Yeh, 2014). Variety of plan on production planning is captivating to be integrated into collaborative manufacturing (Pan et al., 2014). Compared to production planning in a single organization, discussing the integration of these two areas takes more work.

Innovation which is circular in nature seeks to resolve sustainability become an interesting topic in Collaborative New Product Development (Brown et al., 2021). Eco-design product concept was developed for products regarding the impact on the environment. Collaborative Eco-design approach were proposed by Cicconi (2020) to overcome traditional limits using an interactive approach. Research on NPD also needs to consider multi-disciplinary aspects. Due to the lack of interdisciplinary collaboration in the conventional design process, communication hurdles between design phases and a gap between product design and prototype production emerge.

3.3.2.1. Mathematical Model Objectives

The third column objective function and/or decision variable used in mathematical model on production planning, Collaborative Manufacturing and integrating production planning in Collaborative Manufacturing. This research classified the objective function based on research conducted by Akbar & Irohara (2018) which divided into 3 categories: Economic-oriented Objective Function, Environment-oriented Objective Function, Social-oriented Objective Function. Based on these 3 categories, the selected reference articles can be grouped into as follow:

1. Economic-oriented Objective Function, this objective function is usually related to the costs or benefits associated with units of money. As an example, Zhang et al. (2015) studied on minimizing total operating costs to manage product transitions. Decision variables in this model are: duration of the product production period, the quantity of production resources, and the number of setups for both products throughout the ramp-down and ramp-up periods. Chargui et al. (2019) also discussed cost optimization especially in energy cost. On managing product transition, Kwon and Seo (2013) proposed model to minimize total operating costs to manage product transitions. Pan et al. (2014) also integrated production planning into collaborative manufacturing while reducing total cost. Wang and Yeh (2014) studied Aggregate Production Planning (APP) to keep overall costs within a planned horizon as low as possible.
2. Environment-oriented Objective Function, which aims to achieve equilibrium in the use of resources for production in terms of the social, economic, and environmental aspects. According to Cheng et al. (2020), production-related emissions may be decreased by investing on energy-efficient and highly productive machinery; and allocating production capacity while accounting for emissions, inventories, and production costs. Gong et al. (2019) reduce emissions produced during production through investment on energy efficient, high productivity equipment and allocation of production capacity considering emissions, inventory and production costs.
3. Social-oriented Objective Function, which evaluate the ultimate consumers' quality of the products and services and any delays, shortages, expiry dates, conflict resolution, etc. Sadic et al., (2018) suggested method to enable cooperative information control and analysis platforms. While, Dehdari-Ebrahimi and Momeni-Tabar (2017) solved production planning disagreements, sharing group members' gains through Conflict Resolution (CRP) during group formation. On other subtopic, Triqui-Sari and Hennet (2016) proposed a hyper-network model in distributed and collaborative manufacturing operations. Du and Guo (2016) presented a multi-objective order scheduling issue for production planning that takes into account several plants, departments, and production processes.

3.3.2.2. Modeling Approach

Table 6's fourth column describes the modeling strategy. The modeling approach most commonly used to deal with models on production planning, collaborative manufacturing, and integrating production planning in collaborative manufacturing research is Mixed Integer Linear Programming (MILP) and Mixed Integer Non-Linear Programming (MINLP). As a fact, this strategy was used by 16 out of 25 (64%) of the analyzed publications. The articles divided into two categories: MINLP = 2 articles and MILP = 14 articles. Integer Linear programming (ILP), Dynamic Programming (DP), Stochastic Programming (SP), and Hybrid Chance-Constrained Programming were among the modeling techniques mentioned during the review. Aggregate Production Planning model was solved by one author using the Integer Linear Programming (ILP) method (Wang & Yeh, 2014). Dynamic programming was employed by two authors. In order to provide collaborative platforms for information control and analysis, Jabbari et al. (2022) used MINLP. Dey and Shah (2022) used DP to address the lot-sizing in polynomial-time. The outcome shown that branch-and-bound can be exponentially slower than dynamic programming. Whilst, Triqui-Sari and Hennet (2016) used Stochastic Programming and Genetic Algorithm, Zhu et al. (2022) used a Hybrid Chance-Constrained Programming (HCCP), and Zhang et al. (2021) used MESO (Multi Evolutionary Stochastic Optimization). Chang et al. (2015), also proposed Forecasting model by using a bloxplot grey model. Van Der Heijden and Garn (2013) forecasted DuPont ratios Multivariate statistics using Kernel Density estimation of directional statistics profitability targets. Sadic et al. (2018) combined two methods MIP with Fuzzy TOPSIS, to guarantee all companies attempt to reduce overall energy consumption costs. In Du and Guo (2016), multi objective programming was used to address production planning issues involving several plants and departments.

3.3.2.3. Method for Problem Solver

Regarding the methods for resolving collaborative manufacturing and production planning issues, the algorithm used to tackle these issues was not explained in 13 articles, or 52% of the publications, 12 articles or 48%, employ a particular algorithm. The specific algorithm used in selected paper categorized as mathematical model are Genetic

Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Bee Colony (BC), and Ant Colony (AC). (Liu et al., 2016) proposed Hybrid Bacteria Foraging Algorithm (HBFA). Considering the restricted production capacity and diversity of orders, the operational sequence for determining lot size must be routed to the desired cells for processing in Cellular Manufacturing System difficulties. Late delivery or manufacturing in advance frequently happens at each planning period. The proposed Hybrid Bacteria Foraging Algorithm (HBFA) able to find a solution for this challenging labor assignment issue on production planning. The algorithm was the representation of bacteria evolution operators. The production planning problem was addressed by Charles et al. (2022) using MINLP to solve multi-item lot sizing item on planning horizon time.

Alimian et al. (2022) created Rolling Horizon (RH) heuristic methods based on MIP for solving the linearized model of a parallel-line Capacitated Lot-Sizing Problem (CLSP). The model included sequence-dependent setup time/cost, due date, and preventive maintenance planning issues. To address the multi-objective hybrid flow shop scheduling problem, a novel multiphase Iterated Local Search algorithm (ILS) was created. For scenarios with high sample sizes, hybrid metaheuristic offers the advantage of quicker calculation times. The findings of the various algorithms showed that, in big cases, compared to MILP, the hybrid method provided superior results and calculation times that were quicker.

3.4. Answer RQ3: Knowledge Gaps in Current Collaborative Manufacturing and Production Planning and Future Research Direction

From the synthesis and analysis on the section above, it can be identified the knowledge gaps in current collaborative manufacturing and production planning and future research direction, and are summarized in Table 7.

No	Cluster	Current Knowledge	Potential Gaps in Reference	Future Research Direction
1	Collaborative Manufacturing Networks	Collaborative Production Management, matching the requirements to the current outcomes from the field of collaborative networks, Coordination on design and manufacturing activities.	Performance measurement, Technical/operational level in Collaborative Manufacturing Networks	Use Collaborative Manufacturing Networks in more technical way, performance measurement of Collaborative Manufacturing Networks
2	Production Planning	Aggregate planning, Material requirement planning, Hierarchical production planning, Capacity planning, Manufacturing resource planning, Inventory management, and Supply chain planning	Integrate in to Collaborative Manufacturing Environment	Integrating Collaborative Manufacturing System and Production Planning
3	Collaborative Manufacturing + Knowledge Management	intelligent system which supports a collaboration of experts for developing common knowledge bases in health domain, knowledge impact on energy consumption, Information management, minimise knowledge loss, knowledge transfer, Barrier in knowledge management	Aspect/sub topic in KM that can be explored: KM retention, KM storage, KM transfer, KM sharing, Intellectual Capital (Sankar, Alex, Ramamohan, Chandra & Kumar, 2020), knowledge diffusion, case and effect (Antuness & Pinheiro, 2019)	Case studies and effect applied in another field study, focus on aspect/sub topic that have not been studied yet. In example: KM retention, KM storage, KM transfer, KM sharing, Intellectual, knowledge diffusion

No	Cluster	Current Knowledge	Potential Gaps in Reference	Future Research Direction
4	Collaborative Manufacturing + Small Medium Enterprise	Internalization of SME, Multi agent collaborative manufacturing in SME	Innovation efficiency (Lee, Kim & Choi, 2019), Research and Development (Caloffi, Mariani, Rossi & Russo, 2018)	Considering several topics such as innovation efficiency, R&D, etc.
5	Collaborative Manufacturing + Internet of Thing	IoT to manage resource, multi agent CM in SME	Rapid Prototyping (Gianni, Mora & Divitini, 2019), intelligent decision making (Garcia-de-Prado, Ortiz & Boubeta-Puig, 2017)	Use advanced manufacturing technology such as Rapid Prototyping, Use IoT in Decision Making
6	Collaborative Supply Chain Management	FRISCO assessment, green CSCM, cost minimization	Maritime port logistic (Ascencio, González-Ramírez, Bearzotti, Smith & Camacho-Vallejo, 2014), Artificial Intelligence (Carlo et al., 2021)	Expand in another company type such as maritime port logistic and use another method such as Artificial Intelligence
7	Collaborative Manufacturing + New Product Development	Effort, revenue, cost sharing; instrument to find partner, interactive between stakeholder; multidisciplinary, implemented the DoE	Project fail and success (Balzano & Marzi, 2023), early stage NPD (Purnama, Subagyo & Masruroh, 2023)	Fail and success in NPD project, stage in NPD
8	Collaborative Human-Robot	H-R interactive sensor based, general library, virtual reality, cognitive characterization in assembly system	Sustainable Manufacturing (Hjorth & Chrysostomou, 2022), machine learning (Semeraro, Griffiths & Cangelosi, 2022)	Expand on sustainable manufacturing field, use machine learning
9	Collaborative Manufacturing + Decision Support System	Sustainability of providing goods, collaborative DSS	Data driven simulation (Mahmoodi, Fathi, Tavana, Ghobakhloo & Ng, 2024), fuzzy DSS (Erozan, 2019)	Use data driven simulation, considering fuzzy data in DSS
10	Collaborative Manufacturing + Production Planning	CM+PP+order splitting time windows	Explore decision level and method in production planning, Lagrangian heuristic (Wolosewicz, Dauzère-Pérès & Aggoune, 2015)	Combine every method and decision level in production planning in to collaborative manufacturing environment
11	Method	Review, Framework, Survey, Case studies	Simulation, Design Experiment, Game Theory	Case studies and survey in different field study and company, simulation method, Design of Experiment, and Game Theory
12	Mathematical Modeling	Most articles use deterministic parameter, rarely considering stochastic, and uncertainty parameter	Mathematical modeling considering decision level in production planning, consider the uncertainty or stochastic parameter	Multiobjective optimization, Fuzzy Programming consider the uncertainty or stochastic parameter
13	Problem Solver	Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Bee Colony (BC), EA (Evolutionary Algorithm) and Ant Colony (AC).	Other heuristic/ metaheuristic: see (Guzman et al., 2021: page 18) Lagrange Relaxation (Akbar & Irohara, 2018)	Use another heuristic/metaheuristic /matheuristic algorithm. Use Lagrange to relax the constraint

Table 7. Knowledge Gaps in Current Collaborative Manufacturing and Production Planning and Future Research Direction

3.4.1. Knowledge Gaps

The following list summarizes the study opportunity in collaborative manufacturing and production planning and define the knowledge gaps based on Table 7. The opportunity in Table 7 is determined based on the selected primary studies and several articles outside the selected primary studies. Knowledge gaps for each research focus can be summarized as follows: Current research examines collaborative networks or collaborative manufacturing studied Collaborative Production Management, matching the requirements to the current outcomes from the field of collaborative networks, Coordination on design and manufacturing activities (Graça & Camarinha-Matos, 2017). An opportunity in the collaborative manufacturing system which can be explored further is performance measurement. Most studies in Collaborative Manufacturing Networks categorized in conceptual level and does not include operational level. While managing their networks, collaborative manufacturing should not merely focus on strategic issues. It is preferable to give more consideration to the more technical oncerns, such production planning, more thought.

Production planning can be divided into Aggregate planning, Material requirement planning, Hierarchical production planning, Capacity planning, Manufacturing resource planning, Inventory management, and Supply chain planning (Guzaman et al., 2021). It is rarely found production planning integrated with Collaborative Manufacturing (Pan et al., 2014). There are open opportunities to explore integration production planning in Collaborative Manufacturing. Current selected articles in Collaborative Manufacturing and Knowledge Management (KM) discussed intelligent system which supports a collaboration of experts for developing common knowledge bases in health domain knowledge impact on energy consumption, information management, minimize knowledge loss, knowledge transfer, barrier in knowledge management. There are opportunities to study KM retention, KM transfer, KM sharing, Intellectual capital (Shankar et al., 2013), and knowledge diffusion case and effect (Antuness & Pinheiro, 2019).

Small and Medium Enterprise (SME) also attracted many several researchers in relevant with Collaborative Manufacturing. The current selected articles discussed Internalization of SME, Multi agent collaborative manufacturing in SME. There are opportunities to study innovation and efficiency (Lee et al., 2019), and Research and Development (Caloffi et al., 2018). Recent Internet of Thing application in Collaborative Manufacturing discussed IoT to manage resource, and multi agent CM in SME. Opportunities in research focus are using advanced manufacturing technology such as Rapid Prototyping (Gianni et al., 2019), and intelligent decision making (Garcia-de-Prado et al., 2017).

Collaborative Supply Chain Management (CSCM) attracted many researchers who studied FRISCO assessment, green CSCM, and cost minimization using mathematical modeling. There are opportunities to expand in another company type, such as maritime logistic (Ascencio et al., 2014) and to use Artificial Intelligence (Carlo et al., 2021). Relevant strategic issues in networks of collaborative manufacturing, such as Collaborative Manufacturing and New Product Development (NPD) has been studied by some researchers. For example, effort, revenue, cost sharing; instrument to find partner, interactive between stakeholder; multidisciplinary, implemented the DoE. There are some opportunities to expand this research focus, such as project fail and success (Balzano & Marzi, 2023) and NPD stages (Purnama et al., 2023).

In Collaborative Human Robot subtopic, recent articles studied H-R interactive sensor based, general library, virtual reality, cognitive characterization in assembly system. There are no selected papers discussed on tactical or strategic level. All selected paper discussed on the operational level. It would be compelling if there was research that studied Collaborative Human Robots at the tactical and strategic levels. In operational level, there are some opportunities to explore: the Human-Robot in sustainable manufacturing (Hjorth & Chrysostomou, 2022) and machine learning (Semeraro et al., 2022). Recent knowledge on CM + DSS discussed sustainability of providing goods, collaborative DSS. There are many opportunities in Decision Support System outside from Collaborative Manufacturing which can be integrated in Collaborative Manufacturing environment, such as data driven simulation (Mahmoodi et al., 2024) and fuzzy DSS (Erozan, 2019).

Integrating Collaborative Manufacturing and Production Planning is a quite new research topic. There are two articles categorized on this matter, such as Pan et al. (2014) and Cheng et al. (2020). There are many opportunities in this research focus. Some opportunities are to explore decision level and method on production planning and to use Lagrangian method (Wolosewicz et al., 2015). Method used in selected articles are Review, Framework, Survey, and Case Studies. There are opportunities to use Simulation, Design Experiment, and Game Theory method. *Mathematical modeling*. Most articles use deterministic parameter, rarely consider stochastic, and uncertainty. There are opportunities on mathematical modeling considering decision level on production planning, and the uncertainty or stochastic parameter. Problem Solvers used in the selected articles are Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Bee Colony (BC), EA (Evolutionary Algorithm), and Ant Colony (AC). There are other problem solvers that can be used in the next research, as mentioned in Guzman et al. (2021) and Lagrangian Relaxation (Akbar & Irohara, 2018).

This study explores collaborative manufacturing networks and production planning from strategic and operational viewpoint, as an effort to close research gaps and address these gaps.

3.4.2. Future Research Direction

The previous two sections covered the current knowledge in collaborative manufacturing, and then a thorough examination was conducted to pinpoint all the influencing variables. Based on non-mathematical and mathematical model categories, objective function, and different solver methods, such metaheuristic and hybrid metaheuristic approach, a classification reference was created. This section assembles an effort to explore which topics could be a trajectory for future studies based on the prior discussion and based on Table 7.

Future research in Collaborative Manufacturing Network is capable of exploring the performance management. It's able to give more technical concerns, such production planning, more thought since the current body of study does not contain any operational analysis and only investigates collaborative networks or collaborative manufacturing from philosophical perspectives. Collaborative manufacturing should not limit its management of its networks to only strategic concerns. Future research in Production Planning can also be integrated with Collaborative Manufacturing. This integrating topic between CM and PP is open to be explored in future research since there is a great deal of variation in both topics. Production planning subtopic, such as Master Production Scheduling, Scheduling, Forecast the incoming demand (Chang et al., 2015), Aggregate Production Planning (Wang & Yeh, 2014), and troubleshooting production planning conflict resolution (Gong, 2020). The level of discussion in Production Planning can be explored into the scope of Collaborative Manufacturing.

Knowledge management is related to how to manage the company's knowledge resources from lost. Discussion of knowledge management includes knowledge transfer, knowledge implementation, knowledge perception, knowledge retention, and knowledge utilization (Marra, Mazzocchitti & Sarra, 2018). It would be convincing if the discussion of knowledge management was not only in one company, but combined the discussion with the topic of collaborative manufacturing. Future research on Small and Medium Enterprise start considering several topics, such as innovation efficiency, Research and Development, etc. in combined with Collaborative Manufacturing research topics.

Future research could also discuss topics which have not been widely studied by researchers, such as CM and Internet of Thing. Further research contemplates to explore a combination of important factors in the Internet of Things to be utilized within the scope of Collaborative Manufacturing. For example, using advanced manufacturing technology, such as Rapid Prototyping (Gianni et al., 2019), and using IoT on decision making (Garcia-de-Prado et al., 2017). In the Internet of Things, institutions, physical resources, business size, and company ownership are becoming critical variables (Varela et al., 2018). Collaborative Supply Chain Management extensively studied in recent years. There are many mathematical models in minimizing CSCM cost, performance assessment, and green CSCM. Future research in CSCM allowed to expand in another company type, such as maritime port logistic (Ascencio et al., 2014) and another method, such as Artificial Intelligence (Carlo et al., 2021).

Future research also allowed to study Collaborative Human Robots at the tactical and strategic levels, since majority research in CHR discuss in operational level, such as interactive sensor based, virtual reality, and cognitive characterization. Future research in this research focus could expand on sustainable manufacturing (Hjorth & Chrysostomou, 2022), and use machine learning (Semeraro et al., 2022). Future research in Collaborative Manufacturing and New Product Development is able to expand the failure and success of the project (Balzano & Marzi, 2023), and stages in New Product Development (Purnama et al., 2023).

Future research Collaborative Manufacturing and Decision Support System is able to use data driven simulation (Mahmoodi et al., 2024) and to consider using fuzzy data in DSS (Erozan, 2019), since the data in real world problem is not the only deterministic variable. Future research in Production Planning can also be integrated with Collaborative Manufacturing. This integrating topic between CM and PP is allowed to be explored in future research since both topics have wide range. Production planning subtopic, such as Master Production Scheduling, Scheduling, forecast the incoming demand (Chang et al., 2015), Aggregate Production Planning (Wang & Yeh, 2014), and troubleshooting production planning conflict resolution (Gong, 2020). The level of discussion in Production planning is able to be explored into the scope of Collaborative Manufacturing. Future mathematical modeling in integrated Collaborative Manufacturing and Production Planning is allowed to study several aspects in Collaborative Manufacturing, including minimizing collaborating cost, maximizing profit, and increasing resource utility. There is a wide-open aspect which is allowed to be considered in future research.

Regarding the method, the recent selected articles use review, framework, survey, and case studies. Future research is able to study the application of those methods in different field study and company, use simulation, design of experiment, and Game Theory. An approach using simulation is allowed to be a better option, because it is able to create several improvement scenarios without changing the real system (Moharrami, Taghaddos, RazaviAlavi & AbouRizk, 2021).

Regarding the mathematical model, future research may develop model by using multi-objective optimization, Fuzzy programming, and consider uncertainty or stochastic parameter. For example, in the previous section there was research on subtopic scheduling that used multi-objective modeling (Guo & Zhang, 2019). Multi-objective programming can be developed into research on collaborative manufacturing. It is fascinating to develop, to obtain the achievement of different objective functions in one simultaneous model. For future research, the objective function in collaborative manufacturing is able to be combined with the objective function in Collaborative Manufacturing. Actual data in the industry also major, since the research which employs case studies or real data in the field is rarely found. For example, in the selected articles, some only has a small size numerical data on their mathematical model (Du & Guo, 2016; Kwon et al., 2021; Pan et al., 2014). Numerical data is indeed able to describe complex systems on a simple form, but the level of application to real systems still requires many stages before the system is properly completed.

Regarding the type of modelling solver approach, future research could also develop heuristic or metaheuristic methods to save computational time. There are lots of matheuristic (mathematical), metaheuristic, and heuristic approaches developed in recent years (Guzman et al., 2021) which are able to be applied in several cases, including on integrating collaborative manufacturing and production planning topic. As the alternative way, Lagrange Relaxation can also be used to relax the constraint (Akbar & Irohara, 2018).

4. Conclusions

This article discussed the need of integrating two large topics: Collaborative Manufacturing Networks and Production Planning. Both production planning research and collaborative manufacturing research have been extensively studied in literature. However, there is only few research which combines collaborative manufacturing networks with production planning (production scheduling, lot sizing, and buffer). In order to help many businesses to adopt greater technical collaboration among themselves, by considering a variety of production planning variables this study seeks to provide a comprehensive point of view of the present state of research, the direction of collaborative manufacturing, and its application. Therefore, the paper aims to explore the various methods/approaches for incorporating observational data in Collaborative Manufacturing, Production Planning, and integrating production planning in Collaborative Manufacturing through a systematic literature review using the SLR framework, from which 62 studies were analyzed. An overview of the factors affecting collaborative manufacturing and production planning is the first of the study's conclusions. The second conclusion is the existing several concepts, methods, and mathematical models in collaborative manufacturing and production planning that has been identified. There are several Mathematical Programming methods, such as Dynamic Programming (DP), Mixed Integer Linear Programming (MILP), Integer Linear Programming (ILP). Pareto Optimization (PO), Multi Objective Programming (MOP), Stochastic Programming (SP), Mixed Integer Non-Linear Programming (MINLP), Hybrid Chance Constrained Programming (HCCP), and Fuzzy TOPSIS. Metaheuristics that used in the selected studies are Multi Evolutionary Stochastic Optimization (MESO), Grey Model (GM), Multivariate Statistic (MVS), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Neural Networks (ANN), Bee Colony (BC), Ant Colony (AC), Hybrid Bacteria Foraging Algorithm (HBFA), Branch and Bound (BB), Iterated Local Search (ILS), Evolution Algorithm (EA), and Coyote Optimization Algorithm (COA). This paper contributes to the Collaborative Manufacturing literature by providing the advantages and disadvantages of using mathematical programming and metaheuristic and potential gaps found in the literatures. Third, future perspectives for integrating Collaborative Manufacturing and Production Planning research are presented. The study's conclusions are useful to various stakeholders, such as managers, owners, and decision-makers of the business. First, by carefully weighing the possible benefits and costs of carrying out this study, it is suggested to manage a strategic approach to the integration of production planning in collaborative manufacturing networks. Second, our research is allowed to help managers of the organization to make decisions about resource allocation and technology implementation. Third, there is a chance of production planning and collaborative manufacturing to be used more widely. Fourth, since this is a novel study which suggests integrating collaborative maintenance and Production Planning, researchers and scholars are welcome to examine it more thoroughly. Fifth, the company owner and company management is able to prepare what is needed to address the difficulties of making this suggested study applicable to real-world industries.

Author Contribution

Authors MKH and AS evaluated the sample selection protocol and evaluated the caliber of the included studies. Author MSAK conducted the study and compiled the literature in accordance with the methodology outlined, wrote the first draft of the manuscript. MKH and AS contributed to the final version and offered several recommendations to enhance the caliber of the systematic literature review. After reading the work, all writers approved its submission on its current format.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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