A systematic literature review of modelling approaches and implementation of enabling software for supply chain planning in the food industry

David Stüve\(^a\), Robert van der Meer\(^a\), Mouhamad Shaker Ali Agha\(^b\) and Matthias Lütke Entrup\(^b\)

\(^a\)Management Science, University of Strathclyde, Glasgow, UK; \(^b\)Logistics & Operations, International School of Management, Dortmund, Germany

**ABSTRACT**

Advanced Planning Systems (APS) can contribute to improved decision-making and enhanced efficiency along complex food supply chains. This paper presents a systematic literature review of three increasingly important supply chain planning (SCP) tasks supported by APS, namely Supply Chain Network Design (SCND), Sales & Operations Planning (S&OP) and Production Planning & Scheduling (PP&S). Furthermore, academic literature on the implementation of software tools for SCP practices is investigated. The literature review reveals that multiple models for SCP practices have been developed. Empirical literature including case studies on the implementation of APS is sparse. The findings suggest that developed models for the examined planning tasks are implemented to a limited extent in practice. The study can help practitioners in the food industry to get insights regarding the opportunities by the areas of SCP examined in this paper. A theoretical framework providing research propositions to enhance the understanding of APS implementation is introduced.

**1. Introduction**

Supply chain management (SCM) in the food industry is complex. In contrast to other industries, the quality of products continuously deteriorates as the products move along the supply chain (Akkerman et al., 2010). The dynamics of consumer markets are ever increasing (Bowen & Burnette, 2019). Food characteristics such as perishability and cooling requirements need to be considered to satisfy the quality requirements of consumers and to prevent food waste. Consumer attitudes are constantly changing, leading to mass customization and a growing amount of product variants (Trienekens et al., 2012). Consumer demand fluctuates depending on weather and other factors. Therefore, SCP is essential for food companies to retain an overview of the supply chain (Ivert et al., 2015). Planning problems faced by food companies can be expressed in mathematical models and solved by dedicated software tools (Liberatore & Miller, 2021; Stadtler & Kilger, 2002). APS support long-term, mid-term and short-term decision-making and ensure efficient use of resources along the supply chain.
(Neumann et al., 2002). However, despite the positive impact of APS on operational efficiency, research indicates that software tools for SCP are only implemented to a limited extent in practice (Jonsson & Ivert, 2015; Vlckova & Patak, 2011). Likewise, Jonsson and Holmström (2016) diagnose a gap between research and practice in the literature of SCP.

Corresponding to the complexity of food supply chains and the resulting need for SCP, the purpose of this paper is to improve the understanding of SCP in a specific context, namely the food industry. To achieve this aim, the study seeks to systematically review the modelling research for SCP in food companies as well as the literature on APS implementation to support SCP practices. The literature review particularly considers the context of the application of the proposed methods for SCP, indicating the practical relevance of research. This should provide insights into the opportunities of SCP within different food supply chains. The study will focus on three different planning tasks that become increasingly relevant for food companies, namely SCND, S&OP, and PP&S. In addition, it is examined to what extent the implementation of APS supporting long-term, mid-term and short-term decisions is covered by the research. Research on APS implementation is critical as effective SCP requires support by specific software tools. Besides that, literature regarding technology acceptance related to APS is considered. This may provide insights into the adoption behaviour of companies concerning software tools for SCP. Similar literature reviews have been conducted by Ahumada and Villalobos (2009) and Akkerman et al. (2010). The former review concentrates on planning models for the agriculture industry; furthermore, modelling approaches are distinguished based on decision variables, and not based on APS modules. The latter review is focused on models for food distribution emphasizing sustainability and food quality. This study presents a more holistic view on supply chain planning in the food industry covering strategic, tactical and operational supply chain planning models. In addition, the modelling research is contrasted with the state of literature on APS implementation.

The remainder of this paper is structured as follows: In the next section APS is introduced and it is argued why the three mentioned modules are of increasing relevance for the food industry. Subsequently, the purpose of the systematic literature review and the research approach for the literature review are specified. After that, selected research papers on SCP in the food industry are categorised based on the three planning tasks and the application context is presented. Thereafter, research papers on APS implementations are investigated. This section is followed by a short review on the technology acceptance of APS. After that, insights from the literature review are discussed and a theoretical framework is introduced that provides explanations for the findings from the literature review. Finally, findings are summarized in the conclusion and recommendations for further research are provided.

2. Advanced planning systems

The application of APS can address the complexity of food supply chains and conflicting objectives faced by industry managers. APS comprise different software modules involving different functionalities and planning tasks, respectively. Figure 1 provides an overview of software modules covered by APS. The framework is adapted from Stadtler and Kilger (2002). The figure distinguishes between software modules based on the respective dimensions of the planning horizon (from transaction to long-term) and supply chain process (from procurement to sales). At the strategic level, long-term
decisions about the configuration of the supply chain are met (e.g. production and warehouse locations). At the tactical planning level, demand forecasts and mid-term production planning are synchronized. Dedicated S&OP software can support this process. Inventory planning is also carried out at this level. At the operational level, the mid-term plans are broken down into specific production and distribution plans. Supplier relationship management and order management modules serve as interfaces to suppliers and customers for integrated planning along the entire supply chain. Risks in the supply chain can be identified, assessed and reported by dedicated risk management software. In addition, software solutions in the area of supply chain visibility and business analytics can enhance transparency along the supply chain and visualize the performance of the entire supply chain using selected KPIs. New digital technologies for SCP have entered the dynamic software market in recent years (Patsavellas et al., 2021). The framework can be considered as an attempt to provide an up-to-date overview of digital systems for SCP and goes beyond the software modules and decision support systems discussed by Stadtler and Kilger (2002) or Liberatore and Miller (2021).

The aforementioned challenges within food supply chains are usually addressed in mathematical models of operations research to support long-term, mid-term and short-term decisions. These can be speedily solved by means of such software modules. Moreover, APS ensure increased flexibility in case of deviations from the original plans and capture interdependencies of planning decisions (Stadtler & Kilger, 2002).

The present paper focuses on three APS modules, namely SCND, S&OP, and PP&S. Typical functionalities of the respective modules are depicted in Table 1. The importance of strategic decision-making has been growing in recent years. Food supply chains have become global networks responding to consumers’ demand for year-round availability of products. Food products are increasingly produced, processed and distributed across different countries (Ahumada & Villalobos, 2009). Consequently, decisions regarding the physical structure of the supply chain are essential for food companies.
Responding to frequent new product developments, demand fluctuations and supply uncertainties, food producers require a well-functioning S&OP process to coordinate the demand – with the supply side (Ivert et al., 2015). Moreover, products and raw materials may perish if demand is not well-matched with production, reducing overall profitability (Patak & Vlckova, 2012). The process can be supported either by separate demand and supply network planning modules or by an integrated software solution.

Furthermore, complexity in production planning and scheduling is amplified due to increased product variety as a consequence of mass customization (Trienekens et al., 2012). For instance, products may have different setup times and production equipment may need to be cleaned after production blocks (Bilgen & Günther, 2010).

### 3. Motivation

Corresponding to the complexities of supply chain management in the food industry such as the limited shelf-life of food products, the increasing product variety and changing consumer demand, SCP is highly critical to retain an overview of the supply
chain. In spite of that, Jonsson and Holmström (2016) have determined a lack of practical relevance in the literature of SCP. Considering the significance of SCP and the relevance of SCND, S&OP and PP&S in the food industry, this research paper aims to summarize the research on these three areas of SCP in the context of this industry. In particular, individual modelling approaches and supply chain characteristics including the food product and country under consideration are presented. Therefore, to get an overview of academic literature on SCP in the food industry, this literature review aims to address the following question:

(1) To what extent does the academic literature investigate SCP practices that can be associated with SCND, S&OP or PP&S in the food industry?

Next, the literature on the use of software tools for SCP is examined. APS is acting as an enabler for SCP and offers several benefits that have already been mentioned in the previous section. Knowledge of the implementation and use of APS is crucial for practitioners as many companies are only able to plan their supply chain effectively with the help of specified software tools. Thus, this literature review is supposed to answer the following question:

(2) To what extent does the academic literature describe the implementation process and use of APS?

Regarding the significance of SCP and the use of software tools to support SCP practices for the efficient functioning of food supply chains, it is also worthwhile to investigate the determinants of software adoption for SCP. A few studies indicate that the implementation of software tools for SCP is rare in practice (Jonsson & Ivert, 2015; Vlckova & Patak, 2011). An enhanced understanding of the determinants of APS adoption by companies could create a better fit between the requirements of the food industry and the functions of APS tools to ultimately enhance the application of APS modules. Consequently, this paper attempts to answer also the following question:

(3) To what extent does the academic literature describe the adoption behaviour of APS by organisations?

The three research questions serve as guidance for the conduct of this systematic literature review. The literature aimed to address the different research questions will be presented subsequently. After that, the findings are discussed and finally summarized in the conclusion.

4. Research approach

A systematic literature review is conducted to better understand the efforts to support more efficient food supply chains through SCND, S&OP and PP&S. This method comprises the identification, selection and assessment of the literature on a certain topic and ensures that research papers are analysed in a structured and repeatable way with academic rigor (Tranfield et al., 2003). The review approach
pursued in this paper comprises four sequential steps (Mayring, 2003). Firstly, the research papers are collected. Studies for review are obtained through Scopus and Google Scholar databases, and snowballing of citations in relevant papers. Both databases have often been utilised for literature reviews in the domain of supply chain management and are well acknowledged sources to gather relevant literature (Asl et al., 2021; Hosseini et al., 2019; Talwar et al., 2021). Keywords used are ‘food industry’, ‘supply chain planning’, ‘advanced planning systems’, ‘supply chain network design’, ‘strategic network planning’, ‘sales & operations planning’, ‘S&OP’, ‘demand planning’, ‘supply network planning’, ‘production planning & scheduling’, ‘production planning’ and ‘production scheduling’. Boolean keyword search was applied to retrieve the research papers (e.g. ‘production planning’ AND ‘advanced planning systems’ AND ‘food industry’). The search string was used to ensure that the gathered papers are related to planning decisions in one of the specific areas of supply chain planning in the context of a food producing company. Studies published between 1998 and 2020 in peer-reviewed journals are considered. In 1998 SAP APO was introduced as software for integrated business planning. Only papers addressing SCP practices of food companies that can be associated with SCND, S&OP and PP&S are selected. Figure 2 illustrates the process of how the final 77 peer-reviewed research papers were selected. Second, collected studies are examined based on year of publication, author, and publishing journal. Papers with the same author, title, volume, issue, and publication date are considered as duplicates and were excluded. Third, studies are categorized according to the three mentioned fields of SCP. Finally, the individual modelling approaches for SCP of the collected

![Flow diagram of paper selection and inclusion/exclusion process.](image-url)
research papers are presented. Characteristics of the targeted food supply chain, including the product and country under consideration, are depicted to indicate the practical relevance of the selected modelling research. Moreover, the methods underlying the respective models are determined. The review further includes an analysis of the literature covering the implementation of APS to support SCP in food companies, as modelling approaches for SCP are normally solved by specialized software modules. Overall, this review of modelling approaches for SCP within food companies and of research on APS implementation as an enabler of SCP is expected to give an indication of the current state of the literature regarding SCP in the food industry.

5. Research segmentation and overview

In this chapter, collected studies are examined based on year of publication, author, and publishing journal. The final list of papers that could be identified through Scopus and Google Scholar comprises 77 peer-reviewed research papers that deal with SCP within the food industry supporting either of the three planning tasks under consideration. In this paper, only a part of the selected papers will be presented as an illustrative example; the full list can be requested from the authors.

5.1. Distribution of papers over the years

In total 22 studies can be categorized as belonging to the domain of SCND. 17 papers are associated with mid-term SCP supporting the S&OP process. The majority of the identified literature, comprising 38 research papers, is aimed at enhancing PP&S. Overall, there was a growing interest in this kind of SCP research till 2015, with a decline in published research papers in the past 5 years (see, Figure 3).

Figure 3. Distribution of papers over time.
5.2. Contributions classified by author

In total, 176 scholars have contributed to the 77 selected research papers for this literature review. Akkerman, Bilgen and Grunow are among the top contributing authors to the domain of SCP in the food industry (see, Figure 4). While Akkerman can be associated with five papers, Bilgen and Grunow are involved in four studies published in peer-reviewed academic journals.

5.3. Contributions classified by journal

Research papers are selected from 29 different academic journals. Among the various journals, International Journal of Production Research, International Journal of Production Economics and European Journal of Operational Research provided the most contributions in the focused areas of SCP for the food industry (see, Figure 5).

Figure 4. Contributions classified by author.

Figure 5. Contributions classified by academic journal.
6. Classification based on problem context

In this section, the individual modelling approaches that can be associated with SCND, S&OP and PP&S are presented. Characteristics of the targeted food supply chain are depicted to indicate the practical relevance of the selected modelling research. The review further includes an analysis of the literature covering the implementation of APS to support SCP in food companies, as modelling approaches for SCP are normally solved by specialized software modules.

6.1. Supply chain network design

Multiple scholars have studied strategic decisions relating to the supply chain design of specific companies in the food industry (see, Table 2). Most of these scholars elaborated models using mixed-integer linear programming (MILP) methods to optimize the configuration of the supply chain. Hosseini-Motlagh et al. (2019), for instance, developed a model enabling a reduction of total costs of a supply chain network. The mathematical model is validated by real data of the wheat supply chain network in Iran and integrates choices regarding location and capacities for silos as well as the selection of transportation modes. Furthermore, different models have been formulated to meet strategic investment decisions. Aras and Bilge (2018) developed a model for a company producing snacks in Turkey. Their model supports long-term decisions concerning the location and timing of a new production facility, capacities and the assignment to customers. Likewise, Wouda et al. (2002) studied the supply chain network of a company operating in the Hungarian dairy industry. Their model is supposed to ascertain the most efficient network design after the acquisition of multiple companies in that industry. Musavi and Bozorgi-Amiri (2017) proposed a hub scheduling model for perishable food supply chains. The approach ensures that the quality requirements of customers are met while overall transportation costs and carbon emissions of vehicles are reduced. Similarly, Mohammed and Wang (2017) investigated a three-echelon meat supply chain and presented a model that involves multiple objectives. The model aims to minimize transportation costs, the number of vehicles needed as well as delivery time, while the optimal number of farms and abattoirs is identified. Further methods have been developed by scholars to optimize material flow within a supply chain network. The model formulated by Khalili-Damghani et al. (2014) considers a multi-objective supply chain under uncertain conditions and is validated by a case study of a seafood producer in Iran. Reiner and Trcka (2004) suggest a product-specific supply chain design model. Their model is applied and verified in a case study of a pasta manufacturer. Several authors

| Paper | Product       | Country | Method                                      |
|-------|---------------|---------|---------------------------------------------|
| Hosseini-Motlagh et al. (2019) | Wheat       | Iran    | Stochastic programming                      |
| Aras and Bilge (2018)          | Snacks       | Turkey  | MILP                                        |
| Musavi and Bozorgi-Amiri (2017)| Perishable food | -     | MILP                                        |
| Mohammed and Wang (2017)       | Meat         | UK      | Multi-objective robust possibilistic programming |
| Colicchia et al. (2016)        | Chocolate    | Italy   | MILP                                        |
| Khalili-Damghani et al. (2014) | Seafood      | Iran    | MILP                                        |
| Reiner and Trcka (2004)        | Pasta        | -       | Simulation                                  |
| Wouda et al. (2002)            | Dairy        | Hungary | MILP                                        |
formulated approaches to include environmentally conscious thinking in their multi-objective models for strategic decision-making. Colicchia et al. (2016), for example, developed a framework to balance their economic and ecological impact, such as the carbon footprint of a company’s distribution network. Their model could be verified based on a case study of a chocolate producer in Italy.

### 6.2. Sales & operations planning

Academics have also developed modelling approaches for S&OP in the food industry (see, Table 3). In their research Nemati et al. (2017) compared fully integrated, partially integrated, and a traditional decoupled S&OP approach. The different methods were defined by multi-integer programming models. A case study in the dairy industry revealed a superior performance of the fully integrated S&OP approach over the other two models. The model by Liu and Nagurney (2012) helps managers to maximize profits while considering the interplay of different decision-makers in a competitive supply chain network. Thus, an equilibrium pattern can be calculated including inventories, prices of products and transactions. Various approaches for demand forecasting exist. Time-series-analysis methods are solely based on past demand assuming patterns of demand over time. The most frequently used methods are the simple moving average and the exponential smoothing method. Causal models assume that demand is influenced by several known factors like weather or temperature (Stadtler & Kilger, 2002).

Supply network planning represents another essential step within the sales & operations process that can be supported by APS. Multiple models have been formulated to address uncertainties on the supply side of the supply chain. Rong et al. (2011) developed a multi-objective method that can be applied for production and distribution planning. Their approach considers economic factors and explicitly models the quality of food products based on the temperature of products during storage and distribution. Thereby, food waste within the distribution network can be reduced. The model is validated in a case study of a supply chain for bell peppers. Likewise, Ahumada and Villalobos (2011) proposed a model for tactical production and distribution planning for a fresh produce grower in Mexico. The perishability of products is taken into account by a loss function and by limiting the storage time. Higgins et al. (2006) formulated a tool to establish an annual schedule for the production and shipping of sugar in Australia. The complexity of the sugar supply chain in Australia stems from the multitude of sugar brands that are produced in different mills and from ships that need to be assigned to the ports while complying with the storage constraints of the individual ports. The authors argue that

| Paper                      | Product                           | Country | Method            |
|----------------------------|-----------------------------------|---------|-------------------|
| Nemati et al. (2017)       | Dairy                             | Iran    | MIP               |
| Sel et al. (2015)          | Yoghurt                           |         | MILP & heuristic  |
| Liu and Nagurney (2012)    | Perishable food                   |         | Algorithm         |
| Ahumada and Villalobos (2011) | Bell peppers & vine ripe tomatoes | Mexico  | MILP              |
| Rong et al. (2011)         | Bell peppers                      |         | MILP              |
| Higgins et al. (2006)      | Sugar                             | Australia | MILP & heuristics |
| Takey and Mesquita (2006)  | Icecream                          | Brazil  | LP                |
| Ioannou (2005)             | Sugar                             | Greece  | LP                |
production and shipping costs could be significantly reduced based on the proposed model. Takey and Mesquita (2006) studied production and inventory processes with the high seasonal demand of a Brazilian ice cream manufacturer. The modelling approach that they developed defines monthly production plans and workforce requirements. The aggregate plans can be transferred into short-term production plans. Further improvements in demand forecasting leading to inventory reductions are advocated by the authors. Furthermore, Ioannou (2005) reports on a reorganisation project in which the distribution network of a Greek sugar producer could be optimized. Newly developed transportation models resulted in essential savings for the company. The method by Sel et al. (2015) supports integrated tactical and operational decision-making for production planning and scheduling. A heuristic is proposed to decompose mid-term planning into short-term scheduling of yoghurt production.

### 6.3. Production planning & scheduling

Several modelling approaches have also been developed for PP&S of food products (see, Table 4). Doganis and Sarimveis (2008), for instance, formulated a method to optimize yoghurt production. The approach ensures efficient use of resources and captures the increased complexity of an enlarged product portfolio. Thus, multiple variables such as fat content of products, processing times, diverse due dates and sequence-dependent setup times are considered. Similarly, Bilgen and Dogan (2015) created a MILP model targeted towards multistage production in the dairy industry. The proposed method determines the optimal timing and quantity of intermediates and final products to be produced over a specific time period. A further approach covering the uncertainty of milk supply has been developed by Guan and Philpott (2011) to support the production planning of a dairy company in New Zealand. Lütke Entrup et al. (2005) integrated shelf life in their models for weekly planning of yoghurt production. The approach by Wari and Zhu (2016) addresses the multi-week production scheduling of ice cream. The model can be used to optimise makespan and includes several constraints such as clean-up sessions and weekend breaks. A method by Kilic et al. (2013) is formulated to solve the blending problem of a flour manufacturer. The tool helps to determine the optimal blending of intermediates to minimise operational costs. Amorim et al. (2012) elaborated an approach for integrated production and distribution planning considering freshness of perishable products besides economic objectives. It is shown that the integrated method contributes to significant savings compared to the decoupled approach, although savings compared to the traditional method decrease the higher the freshness standards.

| Paper                        | Product       | Country       | Method                      |
|------------------------------|---------------|---------------|-----------------------------|
| Wari and Zhu (2016)          | Icecream      | -             | MILP                        |
| Bilgen and Dogan (2015)      | Dairy         | -             | MILP                        |
| Kilic et al. (2013)          | Flour         | -             | MILP                        |
| Amorim et al. (2012)         | Perishable food| -             | MIP & MINLP                 |
| Wauters et al. (2012)        | -             | -             | Algorithm                   |
| Guan and Philpott (2011)     | Dairy         | New Zealand   | Stochastic quadratic model & algorithm |
| Doganis and Sarimveis (2008) | Yoghurt       | Greece        | MILP                        |
| Lütke Entrup et al. (2005)   | Yoghurt       | -             | MILP                        |
Wauters et al. (2012) developed a specialized scheduler that can be integrated in a manufacturing execution system. The proposed approach enables food processing companies to schedule different production orders at the same time. The routing of production orders within a plant layout is optimised. Thereby, the makespan and the quality of the overall production process is enhanced considering the variety of products.

### 6.4. Implementation of advanced planning systems

The literature mentioned above covers multiple mathematical models that are targeting certain planning problems in different food supply chains. Typically, such models are integrated into APS to enhance supply chain efficiency. Despite the complexity of food supply chains and the related significant potential benefits from implementing advanced planning solutions, literature on the implementation of APS is sparse (see, Table 5).

A few studies have investigated the utilization of planning software in food companies. Vlckova and Patak (2011) examined the demand planning practices of four companies including a food company. Their study revealed that demand planning in the food company was performed via excel spreadsheets. According to the authors, effective demand planning involves collaboration across different departments. It is argued that this could be only achieved by utilizing integrated information systems. Likewise, Jonsson and Ivert (2015) found through a survey among Swedish manufacturing companies, including 30 responses from the food industry, that only a small amount of companies were using sophisticated methods for master production scheduling. They found a positive effect on supply chain performance from the application of planning software for master production scheduling. It is argued that advanced methods would lead to more feasible plans.

**Table 5. Research papers on APS implementation in the food industry.**

| Paper                  | Method                                                                 | Objective                                                                                     |
|------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Jonsson and Ivert (2015)| Survey among Swedish manufacturing companies from different industries (including food & beverage) | Determine the impact of different master production scheduling methods on company performance |
| Zago and Mesquita (2015)| Case study of a dairy company                                            | Examine the benefits of using an APS module for S&OP and determine success factors for the implementation of an APS module |
| Ivert et al. (2011)    | Three case studies of manufacturing companies (including a food and a brewery company) | Investigate problems encountered in the different phases of implementation projects of software tools to support tactical production planning |
| Vlckova and Patak (2011)| Interviews with managers from four companies (including one company from the food industry) | Investigate demand planning practices and the use of software to support demand planning       |
| Rudberg and Thulin (2009)| Case study of a company from the farming & food industry                 | Examine how master planning can be enabled by an APS module                                  |
| Jonsson et al. (2007)  | Three case studies (including two cases from the food industry)          | Examine the use and perceived impact of the application of APS modules for strategic network planning and master production scheduling |
| Brown et al. (2001)    | Case study of a company producing cereals and convenience food           | Examine the effects of using software supporting tactical and operational SCP                  |
There are also a few case studies documenting the implementation of APS modules in specific companies. Zago and Mesquita (2015) conducted a case study at a Brazilian dairy company to assess the benefits and risks of the implementation of S&OP software. The study confirms greater planning accuracy providing enhanced control over inventory levels, reduced transportation costs and the opportunity for scenario analysis as the main benefits of the software. Top management support and system integration are mentioned as major challenges in the implementation project. In other research by Brown et al. (2001), the authors describe the application of a planning software by the Kellogg Company to support short-term as well as mid-term decisions. The system is used for weekly production and distribution schedules and monthly decisions on the production capacity of the different plants. According to the authors, production, inventory and distribution costs could be strongly reduced by the implemented system. Rudberg and Thulin (2009) conducted a further case study in the agriculture industry. It highlights that efficiency along the supply chain can be significantly increased by the use of a master planning module. Higher throughput at lower cost and an improved service level combined with lower inventory were observed as major benefits of the software. Further case studies of APS implementation with more complex supply chain structures are recommended by the authors. Jonsson et al. (2007) conducted explorative case studies of three companies using APS software, including two companies from the food industry. One of them, a producer of vegetable oils and fats, implemented a software module for SCND after a merger to analyse the utilization of two production sites and the impact on logistics costs, based on different scenarios. The other company from the grocery industry introduced a new tool for centralised mid-term supply chain master planning. Both cases reveal enhanced collaboration across different functions and increased commitment to the developed plans as major benefits of APS implementation. A further study examined three companies, among them a food and a brewery company, implementing software for tactical production planning. Three different types of problems that occur during implementation projects could be identified, namely, process-, system- and plan-related problems. Process-related problems are associated with difficulties to achieve progress within the project. System-related problems refer to not using the full potential of the software module. The generation of unrealistic plans by the software is considered a plan-related problem. Various propositions regarding the causes of such problems are provided by the authors (Ivert et al., 2011).

7. Technology acceptance and advanced planning systems

Regarding the limited implementation of APS in practice (Jonsson & Ivert, 2015; Vlckova & Patak, 2011) it would be appealing to understand the adoption behaviour of organisations with respect to APS. Davis (1985) has initially put forward a technology acceptance model (TAM) that explains the technology acceptance of end-users based on two determinants, namely perceived usefulness and perceived ease of use. Perceived usefulness can be associated with increased effectiveness and productivity in performing a task. Perceived ease of use is related to convenient usage, intuitive interaction with the system and effortless learning of the skills to use a technology (Davis et al., 1989; Kwahk & Lee, 2008; Shih & Huang, 2009). The model has been validated and employed in various professions, for instance, medicine and logistics (Chen et al., 2009; Walter & Lopez,
TAMs have been applied to understand the technology acceptance of organisations and end-users across different technologies. These include ERP systems (Amoako-Gyampah & Salam, 2004), the internet of things (Gao & Bai, 2014), RFID (Lee, 2009) and others. Different versions of TAMs exist (Parasuraman, 2000; Venkatesh & Davis, 2000; Venkatesh et al., 2003). Multiple models have been extended by further variables to enhance their explanatory power. These include antecedents for technology adoption comprising technological, organisational, environmental factors, or supply chain characteristics (Gao & Bai, 2014; Kamble et al., 2019; Lai et al., 2018; Venkatesh & Davis, 2000).

However, literature regarding technology acceptance related to APS is rare. The literature search by Google Scholar using the keywords ‘technology acceptance’ and ‘supply chain planning’ yields 229 papers. Similarly, ‘technology acceptance’ and ‘advanced planning system’ result in 11 papers. Nonetheless, the literature search including snowballing of citations reveals no peer-reviewed research papers that analyse the factors influencing the usage of APS. The majority of the resulting papers analyse the adoption behaviour of technologies such as ERP systems, blockchain technology or examine challenges of implementation of supply chain analytics in general. Based on an adapted TAM Masood and Sonntag (2020) investigated benefits and challenges regarding the implementation of Industry 4.0 technologies in SMEs. Different authors studied the factors influencing the adoption of blockchain technology in supply chains (Kamble et al., 2019; Wamba et al., 2020). Faisal and Idris (2020) investigated the determinants of supply chain technology adoption in a survey among 106 SMEs from diverse industries in Malaysia. Likewise, Verma and Chaurasia (2019) studied the adoption of big data analytics based on a survey among 231 managers. Puklavec et al. (2018) empirically analysed the influence of technological, organisational and environmental factors on the different adoption stages of business intelligence systems. For their study, the authors considered data of 181 SMEs. Jeyaraj et al. (2006) examined 48 studies on individual IT adoption and 51 studies on organisational IT adoption in a literature review. Similarly, Arunachalam et al. (2018) conducted a systematic literature review on the capabilities needed for the implementation of big data analytics in supply chain management.

8. Theoretical framework

Companies are increasingly analysed in terms of their processes. The concept of process maturity has gained importance in research. The term suggests that processes can be evaluated based on how well a process is defined, managed, measured and controlled (Lockamy et al., 2008). Overall, research agrees that a higher process maturity is linked to increased company performance (Clause & Simchi-Levi, 2005; Lockamy & McCormack, 2004). SCP is defined as a ‘forward-looking process of coordinating assets to optimize the delivery of goods, services and information from supplier to customer, balancing supply and demand’ (Gartner, 2021). Various process maturity frameworks for individual planning practices such as S&OP (Grimson & Pyke, 2007; Thomé et al., 2012) or master production scheduling (Jonsson & Ivert, 2015) exist. While some authors consider information technology as enabling element for mature planning processes (Grimson & Pyke, 2007), software tools are regarded as key drivers for advanced planning practices.
by others (Jonsson & Ivert, 2015; Lapide, 2005). Overall, it is agreed that IT software is a critical factor for mature SCP processes. Software companies have developed APS that incorporate mathematical and statistical models to ensure optimized plans (Lin et al., 2007; Tenhiälä, 2011). SCP is particularly relevant for food companies due to the increasing complexity of food supply chains (Akkerman et al., 2010; Trienekens et al., 2012). However, research indicates that mature SCP is scarce and APS are only implemented to a limited extent in practice (Jonsson & Ivert, 2015; Tate et al., 2015; Vlckova & Patak, 2011).

Jonsson and Holmström (2016) determined a gap between research and practice regarding literature in the domain of SCP. Several weaknesses of research in that field were identified. It is criticized that research does not provide an understanding of how intended and unintended outcomes of SCP are accomplished. According to Jonsson and Holmström (2016), there is also a lack of literature on the challenges of implementing SCP in an organisation and the context of SCP practices is neglected. It is further argued that outcomes are predominantly demonstrated in the form of optimized models, whereas empirical evidence on outcomes of SCP is limited. The scholars follow that research on SCP is not actionable for practitioners and demand field-tested SCP theory. The concept of field-tested academic management research has been put forward by Van Aken (2004). The author called for more prescription-driven research to increase the relevance of management research. This paper complements well with the analysis of Jonsson and Holmström (2016). The literature review focused on three areas of SCP within the context of the food industry and underpins their findings. Multiple modelling approaches have been customized for diverse food supply chain settings. The implementation of such models in practice remains unclear though. The review of the literature further revealed that research lacks explanations for the adoption behaviour of companies with respect to software for SCP. Scholars were less interested in developing further planning models for S&OP and PP&S in recent years (see, Figure 3). A reason for this could be that the modelling research in these areas is saturated. Scholars may have also realised that this research is only appreciated by a small amount of companies that could apply the models in practice.

The theoretical framework illustrated in Figure 6 provides explanations for the low implementation of APS and guides future research to enhance the practical relevance of the literature in the domain of SCP. Regarding the significance of advanced planning software for SCP practices, research on the implementation of planning tools is overdue. Insufficient IT infrastructure being a major driver for mature SCP practices may be an explanation for the less advanced planning practices within food companies. Sophisticated SCP can contribute to enhanced operational efficiency along a supply chain, but also to ecological benefits such as reduced carbon emissions and food waste (Colicchia et al., 2016; Rong et al., 2011). Therefore, it is critical to generate a better understanding of the perceived usefulness and perceived ease of use of software tools for SCP. This will lay the foundation to create a better fit between the needs of the food industry and the feature set of APS tools to ultimately enhance the application of APS modules and thereby increase the efficiency of food supply chains in the future. In particular, antecedents of perceived usefulness and perceived ease of use of software tools for SCP constitute a valuable direction for future research. Regarding software adoption on an organisational level, management support is emphasised as a critical
requirement for technology adoption in literature (Gunasekaran et al., 2017; Wamba et al., 2015). The two variables are expected to positively influence management support. Having determined the usefulness and ease of use of a system, upper management decides whether to contribute resources to a particular implementation project and finally adopt software for SCP.

Different factors may impact the perceived usefulness of software tools for SCP. It is emphasised in the literature that the difficulty of SCP is reinforced in complex supply chains (Soares & Vieira, 2009; Tenhialä, 2011). Advanced planning practices can generate more feasible plans for the supply chain (Jonsson & Ivert, 2015). Setia et al. (2008) highlight that technology adoptions need to be well-considered and contingent on the overall organisation. Companies may not benefit from the new software, if the supply chain is less complex and managers do not require technological support for their decisions as a consequence (Richey et al., 2016). The functionalities of APS can also be considered insufficient. Likewise, software tools may be rejected due to missing functions that would be required for business operations (Ivert et al., 2011; Stadtl er & Kilger, 2002). In addition, software tools for SCP need to be customized to organisational characteristics (e.g. multi-echelon supply chain; (Setia et al., 2008; Shang et al., 2008; Zoryk-Schalla et al., 2004). If company requirements cannot be covered, the perceived usefulness of software solutions is most likely reduced.

The perceived ease of use of APS is similarly influenced by different variables. Companies may decide against software implementation due to bad data quality (Hazen et al., 2014). APS mostly rely on master data provided by the organisation. Accessing data from different departments in an organisation can be challenging, and the validation of data, as well as data cleansing, can be time-consuming (Ivert et al., 2011; Richey et al., 2016). Lack of expertise could also prevent companies from implementing new software. Organisations may not have employees with the necessary educational background or analytical capabilities to handle such systems (Richey et al., 2016). Skills and expertise in a company are recognised as key factors for successful technology implementation (Clause & Simchi-Levi, 2005; Schoenherr & Speier-Pero, 2015). Additionally, external expertise can be obtained by consultancies. These can provide training and support to the business (Ivert et al., 2011). Know-how may increase a company’s endeavour for new software. Furthermore, the integration of a new system

![Figure 6. Adapted TAM.](image-url)
is a critical factor for software implementation. Case studies confirm that the integration of new software with existing IT infrastructure can be challenging (Wiers, 2002; Zago & Mesquita, 2015). Thus, complex interfaces may reduce managers’ perceived ease of use of new systems.

Based on the adapted TAM nine propositions for future research are developed.

(1) An increase in supply chain complexity is expected to have a positive impact on the perceived usefulness of software tools for SCP.
(2) Greater relevance of APS functions for the business is expected to have a positive impact on the perceived usefulness of software tools for SCP.
(3) Greater coverage of company requirements is expected to have a positive impact on the perceived usefulness of software tools for SCP.
(4) Greater expertise within an organisation is expected to have a positive impact on the perceived ease of use of software tools for SCP.
(5) Greater data quality is expected to have a positive impact on the perceived ease of use of software tools for SCP.
(6) An increase in the complexity of required interfaces is expected to have a negative impact on the perceived ease of use of software tools for SCP.
(7) Enhanced perceived usefulness of software tools for SCP practices is expected to have a positive impact on management support for new software.
(8) Enhanced perceived ease of use of software tools for SCP practices is expected to have a positive impact on management support for new software.
(9) Greater management support for the use of software tools for SCP practices is expected to have a positive impact on the adoption of these systems.

By following the research propositions scholars can contribute to an enhanced understanding of the adoption behaviour of food companies regarding software tools for SCP. This may provide insights why companies largely refrain from implementing software for SCP in spite of the great modelling effort in that research domain. It is noteworthy that technology adoption does not automatically translate into promised benefits. The extent of software usage, support inside an organisation and further factors can limit the positive impact of an implemented technology (Setia et al., 2008). The initial phase within an implementation project is still considered critical for successful software implementation (Ivert et al., 2011).

9. Concluding remarks

This literature review aimed to address the academic efforts by scholars on a highly relevant issue for practitioners in the food industry, SCP and the use of APS to support SCP practices. The review has shown that multiple mathematical models of operations research have been developed and customized to complex planning problems within food supply chains. Academics have formulated diverse modelling approaches to support decisions relating to SCND, S&OP and PP&S, taking account of the specifics in different food sectors around the world. The methods are intended to help supply chain managers
to deal with conflicting objectives, a multitude of decision alternatives and uncertainty. Furthermore, a growing number of models have been developed for integrated planning across decision levels (Amorim et al., 2012; Omar & Teo, 2007). The applicability of mathematical models is emphasized by scholars. While most methods are validated by real data, the implementation in practice of a large part of modelling approaches remains vague.

By applying dedicated software tools, the models can be applied within a reduced planning time. APS ensure increased flexibility in case of deviations from original plans and capture interdependencies of planning decisions (Stadtler & Kilger, 2002). The present review has revealed that empirical investigations regarding the implementation of such software are limited to a few case studies. This is unlike research on other IT software aimed at supply chain efficiency, such as ERP systems (Hong & Kim, 2002; Momoh et al., 2010). The implementation of ERP systems differs from APS implementation though (Ivert et al., 2011; Wiers, 2002). Existing research predominantly reports on the benefits of APS (e.g. lower inventory levels; (Zago & Mesquita, 2015). Those papers examining whether APS modules have actually been implemented observe either no utilization or less advanced methods of SCP (Jonsson & Ivert, 2015; Vlckova & Patak, 2011).

The review of the literature has further uncovered a lack of research regarding APS adoption. A majority of the examined literature is concerned with the adoption behaviour regarding technologies such as ERP systems, blockchain technology or investigates challenges of implementation of supply chain analytics in general. Treiblmaier (2019) asserts that technology adoption models should not simply be applied across different technologies. Scholars rather need to take the characteristics of different technologies and the adopting organisations into account when studying the adoption behaviour of such (Treiblmaier, 2019). The developed theoretical framework gives explanations for the low implementation of APS and outlines directions for future research. Considering the positive effect that APS software could have on the efficiency of food supply chains, a better understanding of the perceived usefulness and perceived ease of use of software tools for SCP is needed.

**Notes**

1. An earlier version of this paper was presented at Hamburg International Conference of Logistics 2020 Stüve et al. (2020).

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**ORCID**

Robert van der Meer [http://orcid.org/0000-0002-9442-1628](http://orcid.org/0000-0002-9442-1628)
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