Mühendislik Bilimleri ve Tasarım Dergisi
7(1), 182 – 195, 2019
e-ISSN: 1308-6693

Derleme Makale

Journal of Engineering Sciences and Design
DOI: 10.21923/jesd.414551

Review Article

INTEGRATED SUPPLY CHAIN SCHEDULING MODELS: A LITERATURE REVIEW

Zeynep CEYLAN[1,2*], Serol BULKAN[2], Hakan TOZAN[3]

[1]Ondokuz Mayis University, Faculty of Engineering, Industrial Engineering Dept., Samsun, Turkey
[2]Marmara University, Faculty of Engineering, Industrial Engineering Dept., Istanbul, Turkey
[3] Medipol University, School of Engineering and Natural Sciences, Industrial Engineering Dept., Istanbul, Turkey

Keywords	**Abstract**
Scheduling, *Supply chain,* *Supply chain scheduling.*	Research on integration of supply chain and scheduling is relatively recent, and number of studies on this topic is increasing. This study provides a comprehensive literature survey about Integrated Supply Chain Scheduling (ISCS) models to help identify deficiencies in this area. For this purpose, it is thought that this study will contribute in terms of guiding researchers working in this field. In this study, existing literature on ISCS problems are reviewed and summarized by introducing the new classification scheme. The studies were categorized by considering the features such as the number of customers (single or multiple), product lifespan (limited or unlimited), order sizes (equal or general), vehicle characteristics (limited/sufficient and homogeneous/heterogeneous), machine configurations and number of objective function (single or multi objective). In addition, properties of mathematical models applied for problems and solution approaches are also discussed.

BÜTÜNLEŞİK TEDARİK ZİNCİRİ ÇİZELGELEME MODELLERİ: BİR LİTERATÜR TARAMASI

Anahtar Kelimeler	**Öz**
Çizelgeleme, *Tedarik zinciri,* *Tedarik zinciri çizelgeleme.*	Bütünleşik Tedarik Zinciri Çizelgeleme (BTZÇ) üzerine yapılan araştırmalar nispeten yenidir ve bu konu üzerine yapılan çalışma sayısı artmaktadır. Bu çalışma, bu alandaki eksiklikleri tespit etmeye yardımcı olmak için BTZÇ modelleri hakkında kapsamlı bir literatür araştırması sunmaktadır. Bu amaçla, bu çalışmanın bu alanda çalışan araştırmacılara rehberlik etmesi açısından katkı sağlayacağı düşünülmektedir. Bu çalışmada, BTZÇ problemleri üzerine mevcut literatür gözden geçirilmiş ve yeni sınıflandırma şeması tanıtılarak çalışmalar özetlenmiştir. Çalışmalar; tek veya çoklu müşteri sayısı, sipariş büyüklüğü tipi (eşit veya genel), ürün ömrü (sınırlı veya sınırsız), araç karakteristikleri (sınırlı/yeterli ve homojen/heterojen), makine konfigürasyonları ve amaç fonksiyonu sayısı (tek veya çok amaçlı) gibi özellikler dikkate alınarak kategorize edildi. Ayrıca problemler için uygulanan matematiksel modellerin özellikleri ve çözüm yaklaşımları da tartışılmıştır.

Alıntı / Cite

Ceylan, Z., Bulkan, S., Tozan, H., (2019). Integrated Supply Chain Scheduling Models: A Literature Review, Journal of Engineering Sciences and Design, 7(1), 182-195.

Yazar Kimliği / Author ID (ORCID Number)	**Makale Süreci / Article Process**	
Z. Ceylan, 0000-0002-3006-9768	**Başvuru Tarihi / Submission Date**	11.04.2018
S. Bulkan, 0000-0002-4815-4389	**Kabul Tarihi / Accepted Date**	04.12.2018
H. Tozan, 0000-0002-0479-6937	**Yayım Tarihi / Published Date**	25.03.2019

1. Introduction

In general, Supply Chain (SC) not only involves transporting the needed product from one location to another, but it also covers the entire production of the product, the procurement, outsourcing, inventory and distribution of the necessary raw materials and semi-finished products. The most important goal in Supply Chain Management (SCM) is the coordination and cooperation of all the stakeholders (suppliers, intermediaries, wholesalers, third party service providers, manufacturers and customers) in this supply network. Due to global competition, companies, suppliers, producers, distributors and

* İlgili yazar/ Corresponding author: zeynep.dokumaci@omu.edu.tr, +90-362-312-1919(1098)

customers have realized that coordination is one of the key success factors in achieving efficient and effective supply chain management (Chen, 2010; Çalışkan, 2014; Wang et al., 2014; Pirim et al., 2014).

It is vital for the companies to be able to respond quickly to the needs of each customer in today's competitive environment. The fact that these requests are met by the business requires that not only the operation of the enterprise itself but also every activity of the supply chain is timely and of good quality. Thus, supply, production and distribution coordination decision has become significant problem in SCM for the last few years. For a successful operation, integration of these functions and their simultaneous scheduling in a coordinated manner is critical (Lawrence et al., 2010).

The studies that examine the detailed scheduling problem in the integrated production-distribution models at the operational level are quite new. Hall and Potts (2003) have suggested Integrated Supply Chain Scheduling (ISCS) as a comprehensive tool for cooperation.

Classic scheduling models deal with the production scheduling problem without considering the total cost such as delivering cost, inventory cost, purchasing cost and etc. However, supply chain scheduling models provides a suitable sequence of jobs, machines, batches, etc., taking into account optimization of revenue, cost and customer service levels together in the supply chain.

The integration of supply chain and scheduling is a challenging optimization problem, so recently, researchers have placed increasing attention on to solve it. In the literature, there is extensive research that has been done on integrated scheduling models. There is a steady increase in the number of different types of problems arose in many practical applications. As the scope of supply chain scheduling includes various problems, there is a need for an extensive classification on studies in detail.

This study introduces a comprehensive literature review on the integrated scheduling of supply chain problems. Similarities and differences of ISCS problems were discussed. The various studies in the literature were summarized and classified into several different classes. The purpose of this study is to provide a literature review about ISCS models in the literature to help noticing deficiencies in this area. Thus, it is thought that this study may be used as a guide for researchers working in this area.

The rest of the paper is organized as follows: Section 2 presents a general description by considering the research articles in the literature on ISCS problems. Section 3 presents new classification of ISCS models. Section 4 is the background and review of the literature on ISCS studies based on the new classification. Finally, Section 5 concludes the paper.

2. General Description of Supply Chain Scheduling Problems

In this section, general structures and characteristics of ISCS problems are described. Figure 1 illustrates a general layout of ISCS problem. In the following, a common ISCS problem is explained and related parameters and notations are described. A general ISCS problem can be defined as in the following:

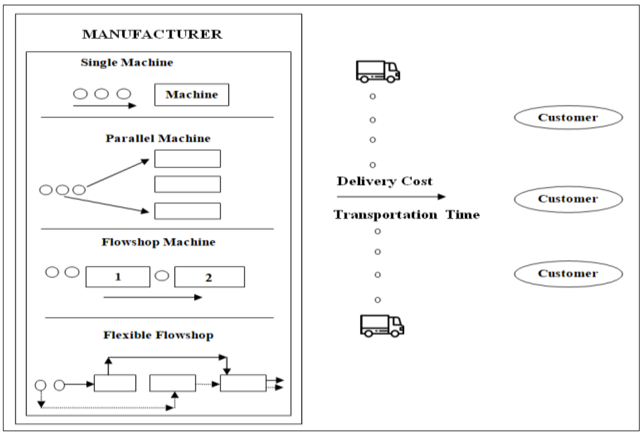

Figure 1. The Layout of Integrated Supply Chain Scheduling

At the beginning of the planning horizon, a producer with one or more facilities receives m orders $(M = 1,2,\ldots,m)$ from c $(c \geq 1)$ customers $(C = 1,2,\ldots,c)$ that can be installed in various locations. $M_i \Subset M$ is the subset of the orders placed by customer i, and $m_i = |M_i|$ for $i \in C$, where $M = M_1 \cup \ldots M_c$, and $m_1 + \cdots m_c$. The orders are manufactured by one or multiple machines and then delivered to the customers individually or in batches by $v \geq 1$ vehicles which can be vans, planes or trucks. Each order $j \in M$ has a processing time p_j if only one machine is required for processing, or p_{ij} on the ith machine if more machines are applied for the production (Chen, 2010).

3. Classification of Supply Chain Scheduling Models

In this section, a brief information about components of ISCS models was given. In Figure 2, the classes which forms the ISCS models are shown.

Each class gives a brief information about number of customers (single or multiple), order sizes (equal or general), vehicle characteristics (limited/sufficient and homogeneous/heterogeneous), machine configurations, product shelf life (limited or unlimited) and number of objective function (single or multi objective), respectively.

Furthermore, other details such as optimality properties, modeling method and solution approaches of the problems also mentioned.

3.1. Order Size

The manufacturer receives orders to process and then delivers the finished orders in batches or individually to the customers. Each order includes a set of products. For example, different orders may have varying order sizes (weight or volume) and the characteristics of the products may be different.

In existing ISCS models in the literature, order sizes are divided into two class: (i) equal size order models; and (ii) different size order models. However, the majority of these studies are equal size order problems (Hall and Pots, 2003; Steiner and Zhang, 2009; Hamidinia et al., 2012; Mazdeh and Rostami, 2014; Ahmedizar and Farhadi, 2015; Hassanzadeh et al., 2016; Marandi, 2017). Due to complexity of modelling, the ISCS problems with different order sizes are more difficult to solve than problems with equal order sizes (Chen, 2010).

3.2. Number of Customers

It is assumed that there are one or more customers in the studies and each customer is located in different places. For this reason, orders from customers in the same location can be combined for delivery. On the other hand, majority the previous studies work on the situations where there are multiple-customers (Chen and Vairaktarakis, 2005; Mazdeh et al., 2011; Rasti Barzoki and Hejazi, 2013; Gao et al., 2015; Cheng et al., 2017; Rostami et al., 2018)). There can be three possible variations: models for single customer, models for multiple customers (c; c ≥ 2) and models for *n* number of customers where each order belongs to a different customer.

3.3. Vehicle characteristics

When an order is produced and completed, it should be delivered to the its customer by various type of vehicles. Because, generally manufacturers and customers are located in different locations. Thus, for each completed order, the decision maker should decide when it will be delivered, which vehicle will be loaded and if there are multiple customers, the route through which the transportation system will be travelled.

The vehicles may be of different types and capacities. Most of ISCS studies in the literature assume either single vehicle or sufficient (unlimited) number of vehicles. However, the number of vehicles available is multiple, but limited in many world applications. Such problems are more difficult than single vehicle or sufficient vehicle problems. Moreover, vehicle capacity may be *limited* or *unlimited*.

The vehicles can be *homogeneous* or *heterogeneous*. If all the vehicles have the same capacity, speed or same fixed and variable cost values, these problems are called as Homogeneous. Otherwise, if one or more features are different for the vehicles, this types of problems are known as Heterogeneous. Few studies in the literature have considered heterogeneous vehicles (Stecko and Zhao, 2007; Ullrich, 2013; Lee et al., 2014; Joo and Kim, 2017; Rafiei et al., 2018; Beheshtinia et al., 2018). The traditional ISCS problems are usually based on a homogeneous fleet size problem and becomes more difficult when the vehicle fleet is heterogeneous. They are also known to be an NP-hard problems.

Furthermore, the most recent studies in ISCS problems are conducted on the third party logistics (3PLs). 3PLs includes part or all of the company's supply chain and logistics operations being carried out by another companies. The usage of 3PLs can improve companies capability in reducing total cost and customer delivery periods. Most 3PL problems assumes infinite number of vehicles available (Stecke and Zhao, 2007, Noroozi et al., 2017, Noroozi et al.,2018)

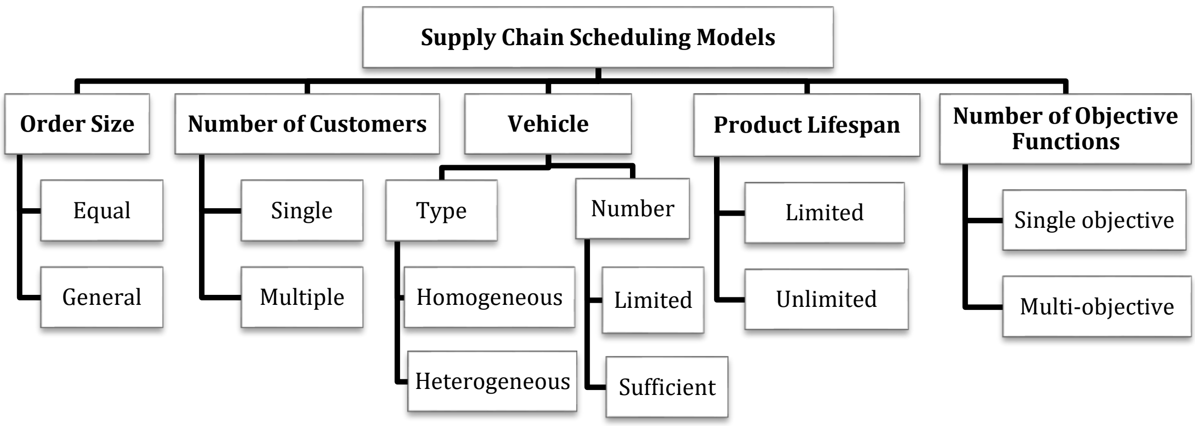

Figure 2. The Classification of ISCS Models

3.4. Machine Configuration

A set of n orders is to be processed at a manufacturing facility. Related with problem characteristics and spesifications, the facility can include a single machine (Mazdeh et al., 2012; Abedi and Seidgar, 2016), a set of parallel machines (Wang and Cheng, 2000, Lin and Jeng, 2004), or a series of flow shop machines (regular flow shop, no-wait flow shop, flexible flow shop, assembly flow shop), jobshops and others. These classical machine structures are considered in below:

- T*he single-machine scheduling configuration* is the most basic structure. One such machine environment all orders are processed by a single machine.

- *Parallel-machine configuration* is similar to the single machine because it is a one-stage processing configuration. However, it includes m identical machines in parallel. Each order needs a single operation and may be processed on any one of the m machine.

- *Flow shop* and *Jobshop Machine configurations* are multi-stage production structures where there are m machines in series. In flow shop machine structure, each order has to be processed by all machines sequentially and all orders follow the same route. On the other hand, the job shop has a more general structure than the flow shop in which each order has its own predetermined route for visiting machines.

- *Flexible Flow Shops (FFS) scheduling configuration* is an extension of simple flow shops that have a special configuration that combines several properties of both the flow-shop and the parallel machine scheduling.

- *Flexible Job Shop (FJS) scheduling configuration* is an generalization of the classical Job Shop which permits an operation to be processed on a given machine by from a given set.

Each these machine configurations has been studied extensively in the literature on ISCS problems and modeled with different constraints, conditions and assumptions according to problem type. Moreover, studies with multi-manufacturing facility (plant) which can be placed in different locations are frequently studied in recent years (Yılmaz and Pardolos, 2017; Rafiei et al., 2018; Beheshtinia et al., 2018). In ISCS models with multiple facilities, each order may be processed different facilities and delivered together.

3.5. Objective Function

Most of the existing ISCS problems are concerned with three basic performance measurements: (i) time-based, (ii) cost-based, and (iii) revenue-based functions.

3.5.1. Time-based objective functions

In ISCS problems, time based measures are same with classical production scheduling problems. The commonly used *time-based performance metrics* are listed below:

- $\boldsymbol{C_{max}}$ = makespan
- $\boldsymbol{L_{max}}$ = maximum delivery lateness
- $\boldsymbol{F_{max}}$ = maximum flow time
- $\boldsymbol{D_{max}}$ = maximum delivery time
- $\sum \boldsymbol{D_j}$ = total delivery time
- $\sum(\boldsymbol{w_j})\boldsymbol{D_j}$ = total weighted delivery time
- $\sum(\boldsymbol{w_j})\boldsymbol{E_j}$ = total weighted earliness
- $\sum(\boldsymbol{w_j})\boldsymbol{U_j}$ = total weighted number of late orders,
- $\sum(\boldsymbol{w_j})\boldsymbol{F_j}$ = total weighted flow time.
- $\sum(\boldsymbol{w_j})\boldsymbol{T_j}$ = total weighted delivery tardiness and etc.

3.5.2. Cost-based objective functions

In this study, cost based performance metrics can be discussed in sub-categories which are (i) total trip-based transportation cost (TC), (ii) total vehicle-based transportation cost (VC), and (iii) total production cost (PC), and others. TC is the total cost for all delivery trips where the cost of a delivery trip can be consist of a fixed cost and a variable cost determined by the shipping path; e.g. total distance regardless of the total distance or the number of shipping orders. VC is applicable in the setting where the use of a vehicle incurs a fixed cost, independent of how many trips it includes. PC shows the production cost of the orders, and to the production schedule (Chen, 2010).

3.5.3. Revenue-based objective functions

Firms are profit-seeking organizations. They attempt to maximize the surplus of income over expenditures within certain limits. Different performance metrics are used in ISCS problems except of these (e.g, capacity utilization of distribution vehicles, quality of service, quality of product, total satisfied demand and etc).

The problems are modeled as minimization if they have goals based on time and cost functions, or sum of these, and are modeled as maximization if they have revenue-based goals. It is always desired that the whole process has a short time, low cost or high profit. But, these objectives may conflict with each other. For example, having fewer vehicles at the delivery of goods may reduce the cost, but can also cause customers to extend the time to receive goods. For this reason, ISCS problem is a multi-objective optimization problem in real life. Many ISCS problems in the literature are aimed at optimizing a single objective or multi-objectives together. In many real world applications, it may be required to focus on multi-objectives at the same time. However, studies dealing with multi objectives are relatively low. There are three common approaches for solution of multi-objective ISCS problems: (i) *Constrained Optimization*, (ii) *Linear Combination*, and (iii) *Pareto Optimization*. Constrained optimization problem is a commonly used method in which one objective is minimized and the other is bounded. In the linear combination method, all objectives are aggregated into a single objective function. In the pareto optimization method, independent objectives are combined to find a well-represented set of pareto-optimal front. Because of complexity of this method, intelligent meta-heuristic approaches (evolutionary algorithms or swarm-based techniques) are used.

3.6. Product Lifespan

Another important feature that directly affects the complexity of the ISCS models is the lifespan of the products. In classic ISCS models, it is assumed that products can be stored and delivered indefinitely without loss of value. However, some types of products may deteriorate over time, or lose value due to changes in fashion or technology. These products have a very short life cycle. For example; after mixing the compulsory raw materials (cement, sand, gravel, water, etc.), the resultant concrete dough becomes solid and therefore useless in an hour. Similarly, after the production of plywood panels, some of the adhesive materials used can lose strength within seven days. Such products should be delivered to the customer immediately after production (Lacomme et al., 2018). Other examples of time-sensitive products include the printing and distribution of newspapers and the processing and distribution of mail [Wang et al., 2005]. In all these cases, it is necessary to schedule the production and delivery of the finished product in an integrated manner.

Studies on products that are quickly perishable in integrated supply chain scheduling problems are considered to be a new field of study in the literature. There are various integrated production and distribution problems in the literature that take into account rapidly perishable products such as fresh food, fruit, fast frozen cement, platelets (Devapriya, 2008; Çalışkan, 2014; Viergutz and Knust, 2014; Lee et al., 2014; Devapriya, 2017; Karaoğlan and Erhan, 2017; Marandi, 2017; Sağlam and Banerjee, 2018). In these models, there is generally a direct connection between production and distribution operations. Due to the nature of the products that are quickly deteriorated, the production systems that produce these products adopt the *make-to-order* philosophy, not the *make-to-stock* philosophy. For this reason, in these type problem, there are zero or almost zero finished product stocks in the production facilities.

3.7. Modeling Methods and Solution Approaches

The ISCS problems are extensively studied in the literature with various models and different objective functions and constraints. Several optimization techniques are used in ISCS problems. Mathematical programming, especially Integer / Mixed Integer Programming has become one of the most commonly applied approach in ISCS problems due to its sensitivity, flexibility and widespread modeling capability (Devapriya, 2008; Ullrich, 2013; Viergutz and Knust, 2014; Pei et al., 2014; Kang et al., 2016; Karaoğlan and Erhan, 2017; Gharaei and Jolai, 2018). The two most important enumerative methods: (i) Dynamic Programming (DP), (ii) Branch and Bound (abbreviated further on as B&B), Branch and Cut (B&C) are commonly used to solve especially small sized ISCS problems.

Moreover, the addition of new constraints and assumptions directly affect the dimension, formulation, complexity, computational time and solution approach of the model. The growth of the model's size causes to the difficulty of solving it with classic analytical methods. It is obvious that the ISCS problems are more complex than classical scheduling problems. Batch delivery problems are strongly NP-hard because of combinatorial complexity. Therefore, the integrated ISCS problems are strongly NP-hard. Because of the difficulty of the problem, optimal benchmark for especially large sized problems cannot computed. Because of the difficulty approximation algorithms, heuristics, meta-heuristics and hybrid meta-heuristics have been developed.

Heuristics are useful and give simple solutions for large scale size problems (Stecke and Zhao, 2007; Rasti Barzoki and Hejazi, 2013; Gao et al., 2015). Meta heuristics such as classical (Simulated Annealing, Tabu Search), nature-inspired algorithms (Ant Colony Optimization, Bee Colony Optimization) and evolutionary algorithms (Genetic and Memetic) are developed for various ISCS problems. Each approach has different properties that make it suitable for application to specific problems. Genetic algorithms have been used in a wide variety of applications.

In recent years, the number of strategies proposed to solve complex optimization problems has increased significantly. For example, hybrid meta-heuristic which is combination of other optimization methods provides more efficient behavior and greater flexibility on complex problems (Hassanzadeh et al., 2016; Noorozi et al., 2017; Yılmaz and Pardolos, 2017; Gharaei and Jolai, 2018). The reason for this is that hybrid meta-heuristics use both their advantages and complementary strengths of, for instance, more classical optimization techniques such as branch and bound or dynamic programming. In this way, more complex but more realistic models can be formulated to obtain good approximate solutions in a reasonable run time.

4. Literature Survey

In this section, the studies on ISCS problems in the literature are classified in tabular forms. As the scope of ISCS involves different types of problems, it is important to examine each selected problem in detail in terms of proper timing and performance. Table 1 gives an overview about several ISCS studies based on the above classification. It also benchmarks the related literature and compares the existing problems. Table 2 presents the mentioned objectives in the ISCS models examined in this paper.

The study of Hall and Potts (2003) is the first study of *Supply Chain Scheduling* in the literature. They integrated scheduling, batching and delivery on a single machine, under the assumption of the existence of batches along with different objectives such as number of late jobs (number of tardy jobs), sum of flow time, total delivery cost, and maximum lateness. They developed an efficient dynamic programming solution algorithm to minimize the above mentioned goals. Chen and Vairaktarakis (2005) studied the integrated scheduling model of production and distribution operations in order to optimize the tradeoff between customer service level and distribution costs. They investigated both single and parallel machine environment. They considered that there were unlimited of vehicles but the capacity of all vehicles was limited. They developed exact and heuristic algorithms to solve the problem. Stecke and Zhao (2007) developed a MIP model for solving of a commit to delivery business mode problem to minimize shipping cost. They provided an efficient and effective heuristic algorithm with polynomial time in order to find a near optimal solution for the NP-hard problem. They considered that transportation was done by 3PLs companies which involve heterogeneous vehicles.

Devapriya (2008) focused on ISCS problem with one production facility and a large fleet size. The problem was modeled considering lifespan of the perishable products. The objective function of problem includes sum of two cost components. First is the variable transportation cost relevant to both plants. Second is the fixed hiring cost of both plants. Steiner and Zhang (2009) have addressed a two-level supply chain scheduling problem with a supplier and multiple customers. In their study, the orders are processed on a single machine and delivered in batches to customers. They proposed an polynomial time approximation algorithm to minimize the sum of the weighted number of late jobs and delivery cost. Mazdeh et al. (2011) developed a Mixed Integer Non-Linear Programming (MINLP) model to minimize the sum of the total weighted number of tardy jobs and delivery costs on the single machine for multiple customers. They used Simulated Annealing (SA) as a meta-heuristic method and compared its results with optimal solutions. Numerical results of study showed that the proposed SA algorithm requires low computation time in terms of the solution performance. Hamidinia et al. (2012) proposed an effective genetic algorithm to minimize earliness, tardiness, delivery and inventory cost in a batch delivery system. The analysis results showed that the proposed genetic algorithm performed better than the classical genetic algorithm under non-batched systems.

Rasti-Barzoki and Hajezi (2013) studied production and delivery scheduling integration problem. They proposed Integer Programming (IP) model and presented a heuristic and B&B algorithm for minimizing sum of the total weighed number of tardy jobs, the total due date assignment costs and delivery costs for multiple customer. The results of study demonstrated that the B&B was more efficient than CPLEX. Ullrich (2013) studied ISCS problem in which jobs are processed on parallel machines with machine-dependent ready times. GA was proposed to solve MIP model. Heterogeneous vehicles with respect to their capacity and ready times were used for transportation of orders to the customers. They showed that the GA outperforms especially for small-size instances.

Viergutz and Knust (2014) studied and extended ISCS problem with lifetime (e.g., perishable or seasonal) constraints. In their problem, there is single product with a short lifetime which is produced at a single production plant with a limited production rate. The model was formulated as maximization problem such that the total satisfied demand is maximized. Lee et al. (2014) formulated a MIP model for a nuclear medicine production and delivery problem to minimize the total system cost including production costs, fixed vehicle costs and travel costs. They used a substance which has a limited half-life. They proposed a variant of a large neighborhood search (LNS) based algorithm and presented a benchmark data set. They showed that the proposed approach performs well on the benchmark instances. Mazdeh and Rostami (2014) extended ISCS problem for a two-machine flow-shop environment. They aimed to minimize maximum tardiness and delivery costs in a batched delivery system. MIP model was provided and solved using a B&B algorithm to obtain the optimum solution. Moreover, they also presented an upper bound (UB) heuristic with a quick processing time.

Table 1. Supply Chain Scheduling Studies Based on the New Classification (Continues)

Year	Author(s)	Order Sizes		Number of customers		Number of objective func.		Product Lifetime		Vehicle Characteristics		Machine configuration	Modeling Method	Solution Approach
		Equal	General	Single	Multiple	Single	Multi	Unlimited	Limited	Type	Number			
2015	Rostami et al.	✔		✔		✔		✔		Homogeneous	Sufficient	Single Machine	MIP	B&B, GA& PSO
2016	Kang et al.		✔		✔	✔		✔		Homogeneous	Limited	Single Facility	MIP	Exact, GA
2016	Assarzadegan and R.-Barzoki	✔			✔	✔		✔		Homogeneous	Sufficient	Single Machine	MIP / MINLP	GA, SA
2016	Hassanzadeh et al.	✔		✔			✔	✔		Homogeneous	Sufficient	Flow-shop	MINLP	Hybrid Metaheuristics
2017	Yılmaz and Pardalos		✔		✔	✔		✔		Homogeneous	Sufficient	Multi-Facility	MIP	Hybrid Metaheuristics
2017	Joo and Kim		✔		✔	✔		✔		Heterogeneous	Limited	Unrelated Parallel Machines	MIP	Exact, Metaheuristics
2017	Noroozi et al.		✔		✔	✔		✔		Heterogeneous	Limited	Single Machine	MIP	Hybrid Metaheuristics
2017	Karaoğlan and Erhan		✔		✔	✔			✔	Homogeneous	Limited	Single Facility	MIP	B&C
2017	Devapriya et al.		✔		✔	✔			✔	Homogeneous	Sufficient	Single Facility	MIP	Exact, GA, MA
2017	Cheng et al.	✔	✔	✔		✔		✔		Homogeneous	Sufficient	Parallel Machine	MIP	Approximation Algorithms
2017	Kazemi et al.		✔		✔	✔		✔		-	-	Flow-shop	MINLP	ICA
2017	Marandi	✔			✔	✔			✔	Heterogeneous	Limited	Flow-shop	IP	Heuristic
2018	Noorozi et al.		✔		✔	✔		✔		Homogeneous	Sufficient	Single Machine	MIP	GA
2018	Gharaei and Jolai		✔		✔		✔	✔		Homogeneous	Sufficient	Parallel Machine	MIP	Hybrid Metaheuristics
2018	Rostami et al.		✔	✔		✔		✔		Homogeneous	Limited	Single Machine	MIP	B&B, SA
2018	Rafiei et al.		✔		✔		✔	✔		Heterogeneous	Sufficient	Multi Facility	MIP	Exact, ECM
2018	Beheshtinia et al.		✔		✔	✔		✔		Heterogeneous	Limited	(Parallel) Multi-Facility	MIP	Hybrid GA

Modeling Methodology : **IP**: Integer programming, **MILP:** Mixed Integer Programming, **MINLP:** Mixed Integer Nonlinear Programming, **DP:** Dynamic Programming

Solution Approach: **Exact:** Exact Solution, **GA:** Genetic Algorithm, **PSO:** Particle Swarm Optimization, **GSA:** Gravitational Search Algorithm, **LNS:** Large Neighborhood Search, **SA:** Simulated Annealing, **B&B:** Branch and Bound, **ECM:** Elastic Constraint Method, **B&C:** Branch and Cut, **MA:** Memetic Algorithm, **ICA:** Imperialist Competitive Algorithm

Table 1. Supply Chain Scheduling Studies Based on the New Classification (Continues)

Year	Author(s)	Order Sizes		Number of customers		Number of objective func.		Product Lifetime		Vehicle Characteristics		Machine configuration	Modeling Method	Solution Approach
		Equal	General	Single	Multiple	Single	Multi	Unlimited	Limited	Type	Number			
2015	Rostami et al.	✔		✔		✔		✔		Homogeneous	Sufficient	Single Machine	MIP	B&B, GA& PSO
2016	Kang et al.		✔		✔	✔		✔		Homogeneous	Limited	Single Facility	MIP	Exact, GA
2016	Assarzadegan and R.-Barzoki	✔			✔	✔		✔		Homogeneous	Sufficient	Single Machine	MIP / MINLP	GA, SA
2016	Hassanzadeh et al.	✔		✔			✔	✔		Homogeneous	Sufficient	Flow-shop	MINLP	Hybrid Metaheuristics
2017	Yılmaz and Pardalos		✔		✔	✔		✔		Homogeneous	Sufficient	Multi-Facility	MIP	Hybrid Metaheuristics
2017	Joo and Kim		✔		✔	✔		✔		Heterogeneous	Limited	Unrelated Parallel Machines	MIP	Exact, Metaheuristics
2017	Noroozi et al.		✔		✔	✔		✔		Heterogeneous	Limited	Single Machine	MIP	Hybrid Metaheuristics
2017	Karaoğlan and Erhan		✔		✔	✔			✔	Homogeneous	Limited	Single Facility	MIP	B&C
2017	Devapriya et al.		✔		✔	✔			✔	Homogeneous	Sufficient	Single Facility	MIP	Exact, GA, MA
2017	Cheng et al.	✔	✔	✔		✔		✔		Homogeneous	Sufficient	Parallel Machine	MIP	Approximation Algorithms
2017	Kazemi et al.		✔		✔	✔		✔		-	-	Flow-shop	MINLP	ICA
2017	Marandi	✔			✔	✔			✔	Heterogeneous	Limited	Flow-shop	IP	Heuristic
2018	Noorozi et al.		✔		✔	✔		✔		Homogeneous	Sufficient	Single Machine	MIP	GA
2018	Gharaei and Jolai		✔		✔		✔	✔		Homogeneous	Sufficient	Parallel Machine	MIP	Hybrid Metaheuristics
2018	Rostami et al.		✔	✔		✔		✔		Homogeneous	Limited	Single Machine	MIP	B&B, SA
2018	Rafiei et al.		✔		✔		✔	✔		Heterogeneous	Sufficient	Multi Facility	MIP	Exact, ECM
2018	Beheshtinia et al.		✔		✔	✔		✔		Heterogeneous	Limited	(Parallel) Multi-Facility	MIP	Hybrid GA

Modeling Methodology : **IP**: Integer programming, **MILP:** Mixed Integer Programming, **MINLP:** Mixed Integer Nonlinear Programming, **DP:** Dynamic Programming
Solution Approach: **Exact:** Exact Solution, **GA:** Genetic Algorithm, **PSO:** Particle Swarm Optimization, **GSA:** Gravitational Search Algorithm, **LNS:** Large Neighborhood Search, **SA:** Simulated Annealing, **B&B:** Branch and Bound, **ECM:** Elastic Constraint Method, **B&C:** Branch and Cut, **MA:** Memetic Algorithm, **ICA:** Imperialist Competitive Algorithm

Table 2. Goals, Objectives and Performance Measures of the Reviewed Studies

Author(s) / (Year)	Maximum Lateness	Maximum Tardiness	Total (Weighted) Tardiness	Total (Weighted) Earliness	Makespan	Average Lead Time	Total (Weighted) Completion Time	Delivery Time	Production Time	Number of Tardy Job	Flow Time	Customer Service Level	Service Span	Fixed Vehicle Cost	Staff Training Cost	Delivery Cost	Hiring Cost (Facility)	Raw Material Cost	Production Cost	Inventory Holding Cost	Earliness Cost	Tardiness Cost	Travel Cost	Service Level	Total Net Profit	Distribution Cost	Transportation Cost	Total Satisfied Demand	Number of Vehicle	Due Date Assignment Cost
Hall and Potts (2003)	✔									✔	✔					✔														
Chen and Vairaktarakis (2005)												✔														✔				
Stecke and Zhao (2007)																											✔			
Devapriya (2008)																	✔										✔			
Steiner and Zhang (2009)										✔						✔														
Mazdeh et al. (2011)										✔						✔														
Ullrich (2013)			✔																											
Hamidinia et al. (2012)			✔	✔												✔				✔										
R.-Barzoki and Hejazi (2013)										✔						✔														✔
Viergutz and Knust (2014)										✔																		✔		
Lee et al. (2014)														✔					✔				✔							
Mazdeh and Rostami (2014)		✔														✔														
Pei et al. (2014)					✔																									
Gao et al. (2015)								✔	✔																					
Fan et al. (2015)								✔								✔														
Ahmedizar and Farhadi (2015)																✔				✔	✔	✔								
Rostami et al. (2015)		✔														✔														
Kang et al. (2016)																			✔								✔			
Assarzadegan&Barzoki (2016)		✔														✔														✔
Hassanzadeh et al. (2016)			✔	✔	✔					✔						✔				✔										
Yılmaz and Pardalos (2017)								✔																						
Joo and Kim (2017)					✔																									
Noorozi et al. (2017)																						✔			✔		✔			
Karaoğlan and Erhan (2017)					✔			✔								✔														
Devapriya et al. (2017)								✔																				✔	✔	
Chen et al. (2017)													✔																	
Kazemi et al. (2017)			✔													✔														
Marandi (2017)					✔																							✔	✔	
Noorozi et al. (2018)																✔						✔			✔					
Gharaei and Jolai (2018)			✔																							✔				
Rostami et al. (2018)							✔	✔																						
Refiei et al. (2018)															✔		✔		✔	✔				✔			✔			
Beheshtinia et al. (2018)								✔																						

Pei et al. (2014) focused on a two-stage supply chain scheduling problem considering multiple manufacturers and different job sizes. The problem was formalized as a mixed integer programming model to minimize the makespan. A global optimization algorithm called Modified Gravitational Search Algorithm (MGSA) is developed to solve the problem. They evaluated effectiveness and efficiency performance of the proposed algorithm, MGSA, compared with PSO and GA. Based on the experimental results, they showed that MGSA has faster convergence speed in solving problems. Ghao et al. (2015) studied the no-wait condition between the production and distribution of each batch with limited vehicle capacity. To minimize the total operating hours required to fulfill a given set of customer orders when the fleet size equals to one. They developed a heuristic with a guaranteed performance. Fan et al. (2015) studied the objective of minimizing the sum of delivery time and total delivery cost caused by one vehicle without capacity constraint. They provided an approximation algorithms to solve the problem. They focused on non-availability single machine constraint (machine can be unavailable due to regular preventive maintenance or unexpected breakdowns). Ahmadizar and Farhadi (2015) extended the problem of Hamidinia et al. (2012) by considering due windows and job release dates. They proposed a solution method with incorporating the dominance properties with an imperialist competitive algorithm. The computational experiments showed that the proposed hybrid algorithm can give optimal or near-optimal solutions in reasonable time.

Rostami et al. (2015) aimed to minimize the sum of maximum tardiness and delivery cost on the single machine with release times. They provided a branch and bound algorithm and two meta-heuristic methods for solving MIP model. The results of study showed that two meta-heuristic methods outperform on extremely large sizes within a reasonable time. Kang et al. (2016) constructed the ISCS problem as MIP model to minimize total production and transportation cost. Then, they proposed Genetic Algorithm (GA) to find near-optimal solutions. In the study, they emphasized that the proposed GA model was an effective and useful method. Assarzadegan and R.-Barzoki (2016) developed MINLP and MIP models to minimization of total costs which includes maximum tardiness, due date assignment and delivery costs. As the developed model is NP-hard, they used meta-heuristic algorithms, an Adaptive Genetic Algorithm (AGA) and a Parallel Simulated Annealing algorithm (PSA) especially large-size instances.

Hassanzadeh et al. (2016) addressed bi-objective production distribution flow-shop scheduling problem. The first objective includes minimization function of makespan and total weighted tardiness. The second objective function aims to minimize of sum of total weighted earliness, total weighted number of tardy jobs, inventory costs and total delivery costs. They proposed two new hybrid meta-heuristics (HCMOPSO and HBNSGA-II) methods to solve the problem. The computational experiments of the study showed the proposed methods outperforms than NSGA-II, MOPSO, NSGA-III and ACO. Yılmaz and Pardalos (2017) extended study of Pei et al. (2014) by including multiple customers. They examined the supply chain scheduling problem with multiple manufacturers and multiple customers in the two-stage that are namely production stage and transportation stage. They developed a mathematical optimization model to minimize the average lead time of the batches. A hybrid Artificial Bee Colony (ABC) and Simulated Annealing (SA) algorithm, namely HABCSA was developed and compared with GA and ABC. Numerical results of study showed that the HABCSA algorithm outperforms the ABC and the GA in terms of the solution performance. Joo and Kim (2017) considered the ISCS problem with unrelated parallel machines, batches, and heterogeneous delivery truck. In order to minimize the makespan of the all process, they developed MIP model. They conducted computational experiments to evaluate and compare the performance of the proposed meta-heuristics on two different problem size.

Noroozi et al. (2017) proposed a new approach of coordination in an integrated supply chain (ISC): coordinating *order acceptance* (OA) and *batch delivery* (BD) due to *round trip transportation* (RTT) and using *third-party logistics* (3PL) vehicles. They proposed a MIP model and solved their model with hybrid evolutionary computation algorithms based on particle swarm optimization (PSO) and genetic algorithm (GA). Karaoğlan and Erhan (2017) studied ISCS problem with limited shelf life product which is produced at single facility. They developed MIP model to minimize the time needed to produce and deliver goods to all customers. They formulated the model with production rate, product lifespan and vehicle (or truck) capacity constraints. They evaluated the performance of the B&C algorithm. Results of study showed that B&C algorithm gave lower and upper bounds very close to each other.

Devapriya et al. (2017) focused on integrated production and distribution problem with perishable product. To minimize the total transportation cost, i.e. the cost of delivery time and the number of vehicles required to satisfy all the demands, they formulated MIP model. They solved small size problem with CPLEX. In order to find approximate solutions for larger problems, they proposed heuristics. Cheng et al. (2017) studied integrated scheduling problem considering production and distribution for manufacturers. The problem involves parallel batch-processing plants and fixed vehicle capasity. In order to minimize service span to respond quickly to the customer, they proposed an approximation algorithm to solve MIP model.

Kazemi et al. (2017) investigated two-stage flow-shop scheduling problem with multiple assembly machines. They presented a hybrid imperialist competitive algorithm (HICA). They proposed mixed integer nonlinear programming model (MINLP) to minimize the sum of tardiness plus delivery costs. Results of study demonstrated that HICA outperformed ICA, but had ICA less runtime than HICA. Marandi (2017) focused on a variation of ISCS problem that contains a short shelf-life product and flow shop scheduling decisions in a single plant. In order to minimize makespan and number of vehicles required to complete the distribution of the products to satisfy customer demand, integer linear programming (ILP) model was constructed. As the proposed model is NP-hard, a new graph-based heuristic method was proposed to efficiently solve the problem.

Noroozi et al. (2018) proposed integrated production-distribution scheduling problem with order acceptance, batch direct delivery, and third-party logistics optimization. In order to maximize benefit, they developed two MIP models and solved them with adaptive search approach (ASA) and adaptive genetic algorithm (GA). Gharaei and Jolai (2018) studied a parallel multi-machine scheduling problem with interfering jobs which belong to two sets of different agents. The first objective function aims to minimize total weighted tardiness of jobs and the second objective function aims to minimize total distribution cost simultaneously. Firstly, a MIP model is formulated for this problem. After that, multi-objective evolutionary algorithm based on decomposition are developed in order to solve the problem. The performance of algorithm has been compared with three common algorithms in the literature. The computational experiments of the study demonstrated that the developed algorithm outperforms than the other tested algorithms.

Rostami et al. (2018) investigated ISCS problem in which both machine deterioration and learning effects were consequently addressed. Single machine and capacitated vehicles were considered. They aimed to minimize the sum of weighted completion time and total delivery time. Results of study demonstrated that the suggested heuristic method had high efficiency to obtain the optimal solution and outperformed to solve large sizes of the problems at a short time. Rafiei et al. (2018) integrated Production-Distribution and transportation planning problem based on a four-echelon supply chain. Bi-objective MIP model was formulated followed by linearization of the nonlinear models. The first objective function aims to minimize total cost of supply chain and the second objective function aims to maximize service level. Adopted Elastic Constraint Method (ECM) method used to solve multi objective models. Beheshtinia et al. (2018) studied integration of production scheduling and vehicle routing in multi-site manufacturing supply chain and multi-suppliers. They introduced Reference Group Genetic Algorithm (RGGA) to solve the ISCS problem. They tested the performance of the algorithm on real data taken from a drug manufacturer in Iran. The computational experiments demonstrated that the RGGA gave better results comparing the obtained results from the real case.

5. CONCLUSION

Nowadays, *Integrated Supply Chain Scheduling* has become one of the most important success factors in order to ensure efficient and effective coordination between companies, suppliers, producers, distributors and customers due to global competition. For this reason, the coordination of production and distribution decisions such as production planning, distribution activities planning, supplier selection, and etc. in recent years has become one of the current issues in supply chain management research for the last few years.

In this study, we focused on chronological summaries of the relevant studies about ISCS problems. Studies were classified with respect to order size, number of customer, number of objective functions, vehicle type, vehicle number, product lifetime, various machine configurations, modeling method, objectives and solution method. With this study, it is aimed to present the studies on supply chain scheduling problems to the readers in tabular form and to give information to the researchers who will interest on this topic.

Several observations can be made from the reviewed studies:

In the vast majority of last studies, orders are processed in batches. Moreover, general order size problems have drawn researchers' attention more than do equal order sizes despite its higher complexity.

Most existing ISCS problems involve limited numbers of homogenous vehicles to describe vehicle characteristics. Few studies consider problems with heterogeneous vehicles. Moreover, the most recent studies are conducted on the third party logistics (3PLs). 3PLs problems generally includes large fleet of vehicles which differ in loading capacity, cost structures, and travel speed restrictions. In such problems, generally it is assumed that there is an sufficient number of vehicles available.

Most of the papers in batch delivery literature are in the single-machine environment, and little work has been done in other environments such as parallel or flow-shop. Furthermore, studies with single or multiple manufacturing facility (plant) which can be placed in different locations are frequently studied in recent years.

Clearly, problems with multiple customers is more general than the case with a single customer. In many models, time-sensitive (e.g., perishable or degradable) products are addressed. Because of lifetime of product, finished order should be delivered to their customer in short time to avoid quality reduction. In such problems, *make to order* philosophy is also adopted.

Cost minimization and service level maximization are most commonly used as objective criterion in the studies. In many real world applications, it may be required to focus on multi-objectives at the same time. However, studies dealing with multi objectives are relatively low. Thus, future studies must focus on multi-objective problems instead of minimizing cost or maximizing service level separately. Because of competitive business environment, companies have to offer high quality service at the lowest possible cost in order to survive.

Several optimization techniques are used in ISCS problems. Mathematical programming, especially Integer / Mixed Integer Programming (MIP) has become one of the most commonly applied approach in ISCS problems due to its sensitivity, flexibility and widespread modeling capability. As a solution method, both exact and heuristic methods are applied to solve the problems. However, most general cases of ISCS models examined in the literature are NP-hard in the strong sense and as a consequence solving these problems with exact methods is hard especially for large size instances. Most studies adopted general heuristics such as meta-heuristics to solve these problems. Especially genetic algorithms is frequently applied as solution algorithm. Thus, a good solution for the integrated problems may be obtained in short computational time.

Conflict of Interest

No conflict of interest was declared by the authors

References

Abedi, M., & Seidgar, H. (2016). A new bi-level meta-heuristic approach for a single machine JIT-scheduling in the batch delivery system with controllable due dates. *International Journal of Services and Operations Management*, *23*(2), 135-152.

Ahmadizar, F., & Farhadi, S. (2015). Single-machine batch delivery scheduling with job release dates, due windows and earliness, tardiness, holding and delivery costs. *Computers & Operations Research*, *53*, 194-205.

Assarzadegan, P., & Rasti-Barzoki, M. (2016). Minimizing sum of the due date assignment costs, maximum tardiness and distribution costs in a supply chain scheduling problem. *Applied Soft Computing*, *47*, 343-356.

Beheshtinia, M. A., Ghasemi, A., & Farokhnia, M. (2018). Supply chain scheduling and routing in multi-site manufacturing system (case study: a drug manufacturing company). *Journal of Modelling in Management*, *13*(1), 27-49.

Çalışkan, E. (2014). Çabuk Bozulabilen Ürünlerde Bütünleşik Tedarik Zinciri Çizelgeleme Problemi için Karışık Tamsayılı Matematiksel Model ve Sezgisel Çözümü, (Doctoral dissertation, Gazi University).

Chen, Z. L. (2010). Integrated production and outbound distribution scheduling: review and extensions. *Operations research*, *58*(1), 130-148.

Chen, Z. L., & Vairaktarakis, G. L. (2005). Integrated scheduling of production and distribution operations. *Management Science*, *51*(4), 614-628.

Cheng, B., Pei, J., Li, K., & Pardalos, P. M. (2017). Integrated scheduling of production and distribution for manufacturers with parallel batching facilities. *Optimization Letters*, 1-15.

Devapriya, P. (2008). *Optimal fleet size of an integrated production and distribution scheduling problem for a single perishable product* (Doctoral dissertation, Clemson University).

Devapriya, P., Ferrell, W., & Geismar, N. (2017). Integrated production and distribution scheduling with a perishable product. *European Journal of Operational Research*, *259*(3), 906-916.

Fan, J., Lu, X., & Liu, P. (2015). Integrated scheduling of production and delivery on a single machine with availability constraint. *Theoretical Computer Science*, *562*, 581-589.

Gao, S., Qi, L., & Lei, L. (2015). Integrated batch production and distribution scheduling with limited vehicle capacity. *International Journal of Production Economics*, *160*, 13-25.

Gharaei, A., & Jolai, F. (2018). A multi-agent approach to the integrated production scheduling and distribution problem in multi-factory supply chain. *Applied Soft Computing*.

Hall, N. G., & Potts, C. N. (2003). Supply chain scheduling: Batching and delivery. *Operations Research*, *51*(4), 566-584.

Hamidinia, A., Khakabimamaghani, S., Mazdeh, M. M., & Jafari, M. (2012). A genetic algorithm for minimizing total tardiness/earliness of weighted jobs in a batched delivery system. *Computers & Industrial Engineering*, *62*(1), 29-38.

Hassanzadeh, A., Rasti-Barzoki, M., & Khosroshahi, H. (2016). Two new meta-heuristics for a bi-objective supply chain scheduling problem in flow-shop environment. *Applied Soft Computing*, *49*, 335-351.

Joo, C. M., & Kim, B. S. (2017). Rule-based meta-heuristics for integrated scheduling of unrelated parallel machines, batches, and heterogeneous delivery trucks. *Applied Soft Computing*, *53*, 457-476.

Kang, H. Y., Pearn, W. L., Chung, I. P., & Lee, A. H. (2016). An enhanced model for the integrated production and transportation problem in a multiple vehicles environment. *Soft Computing*, *20*(4), 1415-1435.

Karaoğlan, İ., & Kesen, S. E. (2017). The coordinated production and transportation scheduling problem with a time-sensitive product: a branch-and-cut algorithm. *International Journal of Production Research*, *55*(2), 536-557.

Kazemi, H., Mazdeh, M. M., & Rostami, M. (2017). The two stage assembly flow-shop scheduling problem with batching and delivery. *Engineering Applications of Artificial Intelligence*, *63*, 98-107.

Lacomme, P., Moukrim, A., Quilliot, A., & Vinot, M. (2018). Supply chain optimisation with both production and transportation integration: multiple vehicles for a single perishable product. *International Journal of Production Research*, 1-24.

Lawrence, K. D., Klimberg, R. K., & Miori, V. M. (Eds.). (2010). *The Supply Chain in Manufacturing, Distribution, and Transportation: Modeling, Optimization, and Applications*. CRC press.

Lee, J., Kim, B. I., Johnson, A. L., & Lee, K. (2014). The nuclear medicine production and delivery problem. *European Journal of Operational Research*, *236*(2), 461-472.

Lin, B. M. T., & Jeng, A. A. K. (2004). Parallel-machine batch scheduling to minimize the maximum lateness and the number of tardy jobs. *International Journal of Production Economics*, *91*(2), 121-134.

Mahdavi Mazdeh, M., Hamidinia, A., & Karamouzian, A. (2011). A mathematical model for weighted tardy jobs scheduling problem with a batched delivery system. *International Journal of Industrial Engineering Computations*, *2*(3), 491-498.

Marandi, F. (2017). A new approach in graph-based integrated production and distribution scheduling for perishable products. *Journal of Quality Engineering and Production Optimization*, *2*(1), 65-76.

Mazdeh, M. M., & Rostami, M. (2014). A branch-and-bound algorithm for two-machine flow-shop scheduling problems with batch delivery costs. *International Journal of Systems Science: Operations & Logistics*, *1*(2), 94-104.

Mazdeh, M. M., Haddadm, H., & Ghanbari, P. (2012). Solving a single machine stochastic scheduling problem using a branch and bound algorithm and simulated annealing. *International Journal of Management Science and Engineering Management*, *7*(2), 110-118.

Noroozi, A., Mazdeh, M. M., Heydari, M., & Rasti-Barzoki, M. (2018). Coordinating order acceptance and integrated production-distribution scheduling with batch delivery considering Third Party Logistics distribution. *Journal of Manufacturing Systems*, *46*, 29-45.

Noroozi, A., Mazdeh, M. M., Noghondarian, K., Rasti-Barzoki, M., & Heydari, M. (2017). Evolutionary computation algorithms to coordinating order acceptance and batch delivery for an integrated supply chain scheduling. *Computational and Applied Mathematics*, 1-51.

Pei, J., Liu, X., Pardalos, P. M., Fan, W., Yang, S., & Wang, L. (2014). Application of an effective modified gravitational search algorithm for the coordinated scheduling problem in a two-stage supply chain. *The International Journal of Advanced Manufacturing Technology*, *70*(1-4), 335-348.

Pirim, H., Al-Turki, U., & Yilbas, B. S. (2014). *Supply Chain Management and Optimization in Manufacturing*. Springer.

Rafiei, H., Safaei, F., & Rabbani, M. (2018). Integrated Production-Distribution Planning Problem in a Competition-Based Four-Echelon Supply Chain. *Computers & Industrial Engineering*.

Rasti-Barzoki, M., & Hejazi, S. R. (2013). Minimizing the weighted number of tardy jobs with due date assignment and capacity-constrained deliveries for multiple customers in supply chains. *European Journal of Operational Research*, *228*(2), 345-357.

Rostami, M., Kheirandish, O., & Ansari, N. (2015). Minimizing maximum tardiness and delivery costs with batch delivery and job release times. *Applied Mathematical Modelling*, *39*(16), 4909-4927.

Rostami, M., Nikravesh, S., & Shahin, M. Minimizing total weighted completion and batch delivery times with machine deterioration and learning effect: a case study from wax production. *Operational Research*, 1-33.

Sağlam, Ü., & Banerjee, A. (2018). Integrated multiproduct batch production and truck shipment scheduling under different shipping policies. *Omega*, *74*, 70-81.

Stecke, K. E., & Zhao, X. (2007). Production and transportation integration for a make-to-order manufacturing company with a commit-to-delivery business mode. *Manufacturing & Service Operations Management*, *9*(2), 206-224.

Steiner, G., & Zhang, R. (2009). Approximation algorithms for minimizing the total weighted number of late jobs with late deliveries in two-level supply chains. *Journal of Scheduling*, *12*(6), 565.

Ullrich, C. A. (2013). Integrated machine scheduling and vehicle routing with time windows. *European Journal of Operational Research*, *227*(1), 152-165.

Viergutz, C., & Knust, S. (2014). Integrated production and distribution scheduling with lifespan constraints. *Annals of Operations Research*, *213*(1), 293-318.

Wang, D. Y., Grunder, O., & Moudni, A. E. (2014). Integrated scheduling of production and distribution operations: a review. *International Journal of Industrial and Systems Engineering*, *19*(1), 94-122.

Wang, G., & Cheng, T. E. (2000). Parallel machine scheduling with batch delivery costs. *International Journal of Production Economics*, *68*(2), 177-183.

Wang, Q., Batta, R., & Szczerba, R. J. (2005). Sequencing the processing of incoming mail to match an outbound truck delivery schedule. *Computers & operations research*, *32*(7), 1777-1791.

Yılmaz, Ö. F., & Pardalos, P. M. (2017). Minimizing average lead time for the coordinated scheduling problem in a two-stage supply chain with multiple customers and multiple manufacturers. *Computers & Industrial Engineering*, *114*, 244-257.