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Queueing Theory Application in Food Supply Chain Management: A Classified Review

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Abstract *– In this paper, the contribution and application of queuing theory in food supply chain management were reviewed. Although many published articles have studied food supply chain management, none of them have focused on the application of queuing theory. This paper first briefly compares queueing theory with other operations research methods and explains the reason for choosing this mathematical method. This review proposes an innovative procedure (based on content analysis) for categorizing food supply chain issues in different areas with queueing theory. We also perform additional content and descriptive analyses to identify trends in the extant literature on food supply chain management and queuing theory application. The results of our investigations are presented based on five perspectives: food supply chain management, decision level, type of food product, queuing system, modeling methodology. Our studies show that extensive gaps are dealing with the topic of this study. Also, a structured summary of each article is presented to provide comprehensive guidelines in this research area. Also, the challenges of this hybrid field were explored, and topics were suggested for future research. The purpose of this paper is to provide sufficient information for researchers who want to use queuing theory in various areas of food supply chain management.*

Keywords*– Agricultural, Classified review, Content analysis, Food supply chain management, Queueing theory.*

I. INTRODUCTION

The food supply chain (FSC) includes the production, processing, distribution, and even food consumption (Orjuela Castro et al., 2017). Although the food industry is proliferating, many FSC-related challenges still exist. The first challenge is to provide enough food for the world's growing population. The population is projected to reach 10 billion by 2050 (Searchinger et al., 2018). According to statistics on the hungry reported in 2017, one in nine people (approximately 821 million people worldwide) have gone hungry (FAO, 2018). Even the FAO predicts that by 2050, more than 40% of animal feed will be consumed directly by humans (FAO, 2013). The next challenge is the loss of food along the supply chain. According to Diaz Allegue et al. (2020), more than 50% of food is lost during the upstream part of the FSC (production, storage, and transportation). Also, during the downstream portion of the FSC (retailers, food services, and consumers), about 30% of food is wasted (porter et al., 2016).

Therefore, food industry managers face many challenges related to increasing their working system's efficiency and effectiveness. On the one hand, they must maintain a high quality of products (in other words, they should prevent food

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wastage); on the other hand, they should be careful about increasing costs.

The food industry is a vast field that can be analyzed in many different ways. Note the following examples.

What is the best decision for new food warehouses' locations, which maintain product quality and have the most demand coverage? How many trucks does a dairy plant need so that the trucks' total distance does not exceed a specified length? How should the milling process of sugarcane be planned for the harvested sugarcane so that there is less waiting in the production line? How should chefs in a fast food restaurant be scheduled to maintain an adequate service level even in the most crowded scenario? How can demand and restaurant capacity be adapted so that customers do not leave the restaurant? How many refrigeration units should be allocated for fresh fruits and vegetables to reduce the amount of perished fruits and vegetables in the supply chain and increase profits?

There are many problems like the above examples in food supply chain management (FSCM). Suitable techniques must be developed to solve these. Operations research (OR) has provided the right platform for solving such problems. OR is a subfield of applied mathematics that is used to improve decision-making processes. According to Churchman et al. (1957), generally speaking, OR is the application of scientific methods, techniques, and tools in systems operations problems so that these systems' operations can be controlled based on optimal solutions. The main tools (techniques) used by OR include mathematical modeling, optimization, statistics, graph theory, game theory, queuing theory, decision analysis, and simulation.

Motivation

The OR in the agricultural food sector has been surveyed since the 1950s (Behzadi et al., 2017). In recent years, many researchers have focused on using OR tools in complex multi-disciplinary FSCM problems (Nematollahi & Tajbakhsh, 2020). Although several review studies have explored the subject of FSCM and the hybrid issue of OR and FSCM, none have specifically reviewed the application of queuing theory.

Queuing theory has significant advantages over other OR tools, which is why this study focuses specifically on this theory (see Section II.B). Queuing theory is one of the oldest and most advanced analysis techniques and is used in waiting lines every day (Cooper, 1980). The main effort of all supply chain components is to satisfy customers. In most cases, customer satisfaction is thought of as a commonly desired feature (Porter et al., 1991). One of these features is access to goods or services in the shortest possible time. Suppliers of goods and services have to use queuing theory to make optimal decisions that reduce customers' waiting time. By doing so, they determine the level of resources needed for investment and ensure customer satisfaction as much as possible. The present paper aims to extensively investigate the queuing theory application (QTA) in the FSCM field (1970-2019). In this paper, we searched for articles whose titles, keywords, or case studies were related to food industry issues – from these, we selected papers that used queuing theory to describe or solve a problem. The present paper aims to study and categorize previous articles related to QTA in food industry management. In addition to introducing the gaps of this hybrid issue (QTA and FSCM), this study can be a comprehensive reference for researchers on this issue. It is important to note that many articles with practical examples in this regard are constantly being published. The present study has been compared to 39 similar papers (see Table I). The main advantages of this study over similar reports are as follows.

- ✓ This is the first research to address QTA in FSCM specifically.
- ✓ This article encompasses a broader range of research (fifty years) than previous studies.
- ✓ This study provides a novel categorization based on the role of queuing theory in the relevant article (based on content analysis)
- ✓ This study provides additional content and descriptive analyses to identify trends in FSCM and QTA research.
- ✓ This study provides a brief description of all the articles used in this study and the application of queuing theory within them (as a guideline for researchers).

The remainder of this paper is organized as follows: In Section II, while introducing queuing theory, the advantage of using this approach is explained in comparison with other mathematical methods. In Section III, the FSC is defined, and due to the wide range of work in this scope, relevant papers are categorized into three groups. In Section IV, the search strategy is presented. In Section V, the selected documents are innovatively organized into three categories (and, more specifically, into corresponding subcategories). In Section VI, the results of content analyses are presented. A summary of the overall research is presented in Section VII as a conclusion. Also, some suggestions are made for future research in this section. Meanwhile, a brief description of all the articles used in this study and the application of the queuing theory within them (as a guideline for researchers) are presented in the Appendix.

Table I. Prior review papers on the context of OR and management of FSC sorted chronologically

Author	*Reviewed subject*	*Time horizon*	*Systematic literature review*	*Type of food*	*Number of reviewed papers*	*Perspectives on the specific subject of OR*	*Perspective on FSC*	*Research focus and objective*
Kutcher & Norton, 1982	FSC-OR	-	No	Agricultural products	-	-	-	Investigating OR methods in agricultural policy analysis
Glen, 1987	FSC- OR	-	No	-	-	-	Farm planning	Reviewing the types of planning models dealing with both the crop and livestock sectors
Hardaker et al., 1991	FSC	-	No	-	-	-	Farm planning under uncertainty	Investigation of risk modeling in agricultural systems
Hayashi, 2000	FSC	-	No	-	-	-	Resource management	Reviewing multi-criteria analyses related to farming resource management
Sundrum, 2001	FSC	-	No	Organic livestock	-	-	-	Exploring the production of organic livestock products with a focus on environmentally friendly production, animal health
Lucas & Chhajed, 2004	FSC- OR	1826-1991	No	-	-	-	Location problem	Reviewing facility location problems and OR techniques in the agricultural field
Lowe & Preckel, 2004	FSC- OR	-	No	-	-	-	Decision technologies	Investigating applications of decision technology tools in relationship agribusiness problems
Weintraub & Romero, 2006	FSC- OR	-	No	Agricultural and forestry resources	-	-	-	Reviewing OR models used for agricultural and forestry resources management
Valenzuela & Villalobos, 2009	FSC	1985-2008	No	Agri-food (fresh and nonperishabl e products)	-	-	Production and distribution planning models	Reviewing the main contributions dealing with the field of distribution and production planning for agri-food networks
Audsley & Sandars, 2009	FSC- OR	-	No	-	-	-	-	Analysis of factors characterizing OR used in the agricultural sector
Higgins et al., 2010	FSC- OR	-	No	-	-	-	-	Reviewing OR applications in agricultural value chains

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Akkerman et al., 2010	FSC	-	No	Food (chilled, frozen, and ambient products)	-	-	Distribution management	Reviewing the quantitative operations management dealing with food distribution
Rajurkar & Jain, 2011	FSC	1994-2009	No	Food	134	-	-	Providing a review, classification, and analysis of literature on food supply chain
Zhang & Wilhelm, 2011	FSC-OR	-	No	Fruits, nursery and floriculture crops	-	-	Decision support models	Reviewing operations management applications in the specialty crop industry
Bhagat & Dhar, 2011	FSC	-	No	-	34	-	-	Studying critical effective factors on agricultural supply chains
Syahruddin & Kalchschmidt, 2012	FSC	1994-2011	Yes	-	80	-	-	Reviewing the application of sustainable supply chain management in the agricultural field
Soysal et al., 2012	FSC	1987-2012	No	Food	36	-	-	Investigating quantitative studies dealing with sustainable food logistics management
Jharkharia & Shukla, 2013	FSC	1989-2009	Yes	Agri-fresh products	86	-	-	Reviewing supply chain management on Agri-fresh-products
Bosona & Gebresenbet, 2013	FSC	2000-2013	Yes	Food	74	-	Food traceability	Exploring studies on food traceability systems and integrating them with logistics processes
Plà et al., 2013	FSC- OR	-	No	-	-	-	-	Propounding the future of OR in the field of agricultural planning
Beske et al., 2014	FSC	-	Yes	Food	52	-	Dynamic capabilities	Performing a literature review to form the link between sustainable supply chain management and dynamic capabilities
Tsolakis et al., 2014	FSC- OR	-	No	Agri-food	-	hierarchical decision-making	-	Presenting a general hierarchical decision-making framework related to stakeholders involved in the agri-food supply chains management

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Soto-Silva et al., 2016	FSC- OR	-	Yes	Fresh fruit	28	-	-	Reviewing OR methods on fresh fruit supply chain
Kusumastuti et al., 2016	FSC	1983-2013	Yes	Crops	76	-	Planning of harvesting and processing	Reviewing the studies on crops
Borodin et al., 2016	FSC- OR	-	Yes	-	111	-	Uncertainty in supply chain	Providing an overview on the application of OR methods in uncertain agricultural supply chain management
Ganeshkumar et al., 2017	FSC	2006-2016	Yes	Agri-food	116	-	-	Reviewing the literature dealing with agri-food supply chain management
Siddh et al., 2017	FSC	1994-2016	Yes	Agri-fresh food	142	-	Supply chain quality	Reviewing the literature on Agri-fresh food quality
Zhong et al., 2017	FSC	1993-2017	Yes	Food	192	-	-	Providing an overview of systems and implementations in food supply chain management
Behzadi et al., 2017	FSC	1993-2015	Yes	-	42	-	Supply chain risk	Reviewing agricultural supply chain management in terms of risk management models
Dania et al., 2018	FSC	1996-2017	Yes	Agri-food	30	-	Collaboration behavioral factors in supply chain	studying the perspective of the state-of-the-art of collaboration on agri-food supply chain
Zhu et al., 2018	FSC- OR	2000-2016	Yes	Food (animal-based and plant-based)	83	-	-	Investigating model-oriented applications of OR techniques in sustainable food supply chains
Mor et al., 2018	FSC	2008-2018	Yes	Dairy products	100	-	-	providing a structured-literature-review on dairy supply chains
Kashav et al., 2018	FSC	2001-2016	Yes	Food	89	-	Cold chain management	Reviewing the literature on food cold chain management
Vrat et al., 2018	FSC	1985-2017	Yes	Perishable food	94	-	Cold chain management	Analyzing the literature on sustainable cold chain management
Stone & Rahimifard, 2018	FSC	-	Yes	Agri-food	137	-	Supply chain resilience	Reviewing of definitions, elements, and strategies applied to resilient agri-food supply chains

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Prakash, 2018	FSC	1995-2017	Yes	Food	99	-	Food processing	presenting a unified combination of articles related to food supply chains in the mutual context of the UK and India
Parajuli et al., 2018	FSC	-	Yes	Fruits and vegetable	176	-	Life cycle environmental footprints	providing environmental sustainability characteristics on fruits and vegetable supply chains in climate change conditions
Lezoche et al., 2020	FSC	-	No	Agri-food	200	-	-	Surveying the supply chains and technologies for the future of Agri-food
Nematollahi, & Tajbakhsh, 2020	FSC	1987-2019	Yes	Agricultural products	247	-	-	providing a systematic review of quantitative studies on sustainable agricultural businesses
Current study	FSC- OR	1970-2019	Yes	All food products (including agricultural and livestock products, beverages, etc.)	102	Queuing theory	-	Providing a systematic review on the queuing theory application in food supply chain management

II. THE QUEUING THEORY

A. What is the queuing theory?

Waiting lines are called queues. We encounter various queues during daily activities. For example, we join a queue to buy bread in a bakery, deposit money at a bank, check in airport security gates, and order food at a restaurant.

The queuing theory was first introduced by Erlang (1913) in the telecommunications facility, and after, it was widely utilized in industrial systems and retail sector operations management.

In a queuing system, customers from a determined crowd arrive at a service facility to receive the service. For each service facility, one or more servers are considered to be able to handle customers. In this system, the queuing phenomenon occurs when the customer finds that all servers are busy taking earlier customers after arriving at the service facility, so they must join a queue until the server is accessible. The customer leaves the queue after receiving the service and will not join the queue again (Lakatos et al., 2013).

The random variables associated with a queueing system are as follows:

- N_q : the number of customers in queue
- N_s : the number of customers who are receiving the service
- N : the total number of customers in the system ($N = Nq + Ns$)

- W : the waiting time, spent times in the queue before receiving the service
- X : customer's spent time to receive the service
- T : sojourn time, the total time a customer pays in the system

The queuing process is shown in *Fig. 1*.

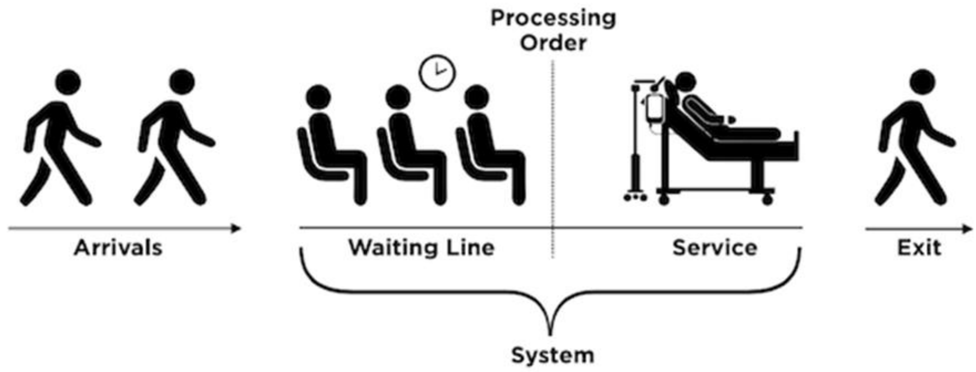

Fig. 1. The queueing process

A queueing system is characterized as follows:

- *Population*: finite or infinite source of the arriving customers at the service facility
- *Arriving pattern*: customer interarrival process

Suppose the first customer at the time s_1, the second customer at the time s_2 and n^{th} customer at time s_n arrives in the system. The time between two consecutive arrivals is calculated as follows;

$$t_1 = s_1, \quad t_2 = s_2 - s_1, \dots, \quad t_n = s_n - s_{n-1} \tag{1}$$

$s_1, s_2, \dots, s_n$ and $t_1, t_2, \dots, t_n$ are all of a random nature. It is necessary to determine the distribution function of these random variables to study the mathematical relationships governing the queuing system. If the distribution function of this random variable is represented as A(x) then,

$$A(x) = p(t \leq x) \tag{2}$$

A helpful quantity to peruse the customer arriving pattern is the customer arrival rate (λ), which is the mean of customers' number coming in per unit time that is defined as the inverse of the average time between two consecutive arrivals.

- *Service time distribution*: elapsed time to serve each customer

The service time is random. Suppose the service time to a customer is X; if the distribution function of this random variable be $B(X)$ then,

$$B(X) = p(X \leq x) \tag{3}$$

In this respect, the service rate (μ) is equal to the number of customers receiving the service from the server at a time unit.

$$\mu = \frac{1}{E(X)} \tag{4}$$

Where $E(X)$ is expectation X.

- *The queueing capacity (finite or infinite capacity): If queue capacity is* limited, the new customer cannot arrive in the queue (blocked queue) when the queue capacity is completed.
- *The number of servers*: The number of servers can be one or more. A queuing system with one server (single-server) can serve a customer, while more than one server (multi-server) can serve several customers simultaneously.
- *Queueing discipline* (service discipline): The rule governing the queuing system to prioritize customers to receive the service (such as FIFO (first-in-first-out), LIFO (last-in-first-out), SIRO (Service in random order), and Priority)

Characteristics of the queue are written in the following abbreviation (the Kendall notation):

$A/B/c/D/E/F$

"A" defines the arrival process; "B" explains the service time distribution; "c" is the number of servers at the queueing station; "D" is the maximum number of allowable customers in the system (system capacity) and the default value is infinity. "E" describes the size of the population, and the default value is infinity; "F" defines the queueing discipline, and the default rule is FCFS.

When default values of D, E and F are used, $A/B/c$ notation is applied instead of $A/B/c/D/E/F$ notation. Besides, the conventional symbols for A and B are defined as follows;

- GI: General independent interarrival time
- G: General service time distribution
- M: Exponential interarrival time or service time distribution (an exponentially distributed interarrival time means that customers arrive at a Poisson process.)
- D: Deterministic/constant interarrival time or service time distribution

B. Why the queuing theory?

As a scientific discipline, Operations research employs appropriate analytical methods for decision-making (since 1930). Linear and dynamic programming models are used as optimization techniques for quantitative analyses. These mathematical models, by neglecting the effects of uncertainty, can model and solve complex decision-making problems.

Simulation models offer an appropriate choice for overcoming the obstacles of model complexity and dynamics (Frijda 1967); however, building large-scale FSC simulation models is not easy. Also, the required large amount of data and the heavy expenses related to such data collection is another obstacle.

One of the significant applications of OR in FSC is in the form of the queueing theory. Queueing models need relatively limited data, so they are fast and straightforward and can be used to quickly evaluate and compare different alternatives for preparing a service (Shortle et al., 2018). In addition to determining how much capacity is needed to attain a specified service standard, queueing models are useful to organize resources and prioritize schemes for choosing the service order. Today, computers can be used alongside numerical methods, simulation models, and queueing theory to help understand real-life queueing systems.

We believe that queuing theory is very beneficial because of the randomness and the need for less information to model FSC issues.

III. FOOD SUPPLY CHAIN

The food industry plays a vital role in supporting human activities and behavior (Cooper & Ellram, 1993). FSCM can be considered in the framework of the production, processing, and transfer of raw and semi-finished products achieved through forestry, agriculture, and animal husbandry (Dubey et al., 2017).

The FSC in this paper includes all the activities related to production, distribution, storage, and transportation of food, agriculture, animal husbandry, and food serving, in fact, "from farm to fork."

Due to the broad scope of the FSC, relevant articles were considered in three main groups in this paper to clarify the research framework. The groups are as follow:

- **The foodstuffs:** This includes all products that are eaten as raw or cooked, such as rice, meat, fruits, vegetables, cheese, alcohol.
- **Restaurants, fast-food markets, and caterings:** This includes all centers of food cooking and serving.
- **Farms, grocery stores, food plants, hubs, and warehouses:** This includes all centers for the production, supply, storage, or distribution of food at different levels of the FSC.

A. Foodstuffs

Foodstuffs include edibles such as dairy products, meat, broiler chicken, agriculture products (such as fruits, vegetables, grains, sugar cane), seafood, and beverages. They can be considered as waiting for customers in a queue. In each queue, operations such as preparation, packaging, quality control, and even digested by the stomach (server) should be performed to serve these customers.

Some related studies have been reviewed. Queuing theory, based on the assumption of finite resources by W. Whitney and Cochran (1976), was applied to forecast the delivery rate of sugarcane to mills for managing the loader-card transport system. Sharan and Madhavan (1999) proposed a mathematical simulation based on dynamical queuing systems to predict and plan the trade of fruits and vegetables. The purpose of this simulation was to increase the level of commerce over the following ten years. Halachmi (2007) considered the edible fish pond as a queuing system and, by introducing a mathematical model, optimized the fish batch arrival time and number (as customers) and the waiting time in each pond system layout.

Nichols et al. (2011) proposed a simulation model for analyzing the environmental factors and the sustainability of food and biofuel products, using queuing theory to control job submissions. Venkatadri et al. (2014) conducted studies on managing the distribution system (DS) of the beverage industry. Initially, they optimized the number of pick locations for each product to locate products in a fast-picking tunnel, thus reducing congestion and improving throughput. Then, they proposed a mathematical simulation model that could evaluate the queuing of given product placement. Mouhaffel et al. (2016) used queuing theory models and agricultural methods to optimize the number of tracks in their transportation system to improve the rice cultivation process.

Hanukov et al. (2019) introduced an approach based on a combination of queuing theory and an inventory model. In this approach, which used the preliminary services (PS) system, the goal was to reduce the total cost of service and sojourn in fast food service. They subsequently optimized the capacity of PS service and investment level by providing an economic analysis. Molnar and Tumik (2018) used an activity-based costing model to eliminate waste in food delivery systems. In the latter model, the parameters of waiting time, input rate, and service rate were considered factors of interest in the queuing system.

B. Restaurant and fast food markets

Despite challenges such as the increasing cost of food, healthcare issues, and sick economy, the restaurant industry (including full-service restaurants and fast food markets) is growing continuously (Roy et al., 2016). Due to food and service quality, value and reputation, price, and location, the restaurant industry is highly competitive. Increased service quality leads to higher levels of customer satisfaction and, consequently, higher levels of customer patronage (Chow et al., 2007).

Specifically, customer satisfaction assessment indices used for restaurants include the following criteria (Roy et al., 2016):

- Food indicator: hygiene, balance, and healthiness
- Physical provision indicator: layout, furnishings, and cleanliness
- Atmosphere indicator: feeling and comfort
- Service received indicators: speed, friendliness, and care

Several papers using the queuing theory approach have been published in this area. Presently, a number of these articles are reviewed. Mesterton-Gibbons (1988) considered a fast-food restaurant that guaranteed it would serve food within t minutes or refund the customer’s money. They modeled the kitchen as a stationary, single-server queuing system. By modeling and solving the problem, they calculated the optimal value for t (t*) and maximized the expected profit.

Parkan (1987) examined the relationship between a fast-food restaurant’s essential operating characteristics and its customers’ behavior. He used a model that calculated waiting times based on service times. The simulation experiments used in this model revealed how the discrepancies between the expected and delivered service speed and quality caused lost patronage in two real-world fast-food and two hypothetical operations.

Church and Newman (2000) introduced a computer simulation to minimize queue length. In their analysis, parameters such as the number of employees, customer arrival rate, processing time, and queue behavior were considered. This research proposed a rather simplistic analysis of UK fast-food retailer’s managers. Lan et al. (2005) studied the finite queuing capacity in a fast-food store to find the optimal number of skillful and unskillful employees and the optimal number of open counters for maximizing profit. They introduced the cumulative probability function of the customer behavior to investigate the system leaving.

Hwang et al. (2010) examined the capacity and demand management problem in a restaurant system. A queueing-based optimization model was developed to address the dynamic and nonlinearity difficulties. The study shows that applying a strategy to balance the service quality and cost can increase profit. Of course, they pointed out that an interdisciplinary perspective of marketing and operations can be used to overcome the traditional view of the conflict between service quality and cost. Raman and Roy (2015) introduced a queuing theory model with an allocation policy for calculating the optimal table mix capacity of a walk-in restaurant. In this model, the cost function consists of two parts: the cost due to the waiting times and the cost due to table capacity underutilization.

Roy et al. (2016) proposed a stochastic model to capture customer waiting times in a restaurant. Their model uses a two-level queueing network to capture the dynamics present in the kitchen processes and customer dine-in processes, and table allocation. In a simulation, they tested the number of chefs assigned to burners and the different capacities for each table. Hanukov et al. (2017) studied a single-server queue in a fast-food restaurant where service consisted of two independent stages. The first stage was public and can be done even in the absence of customers (‘preliminary’ services), while the latter required the customer to be present. Using this approach in a case study, they could reduce customer waiting times and increase profits.

C. Farms, grocery stores, food plants, hubs, and warehouses

Food plants, farms, grocery stores, food hubs, and food warehouses are centers for the production, supply, storage, or distribution of food at various levels of the food industry supply chain. These centers have specific capacities that should serve several customers at a specified time and with a limited number of servers.

Because these centers play a significant role in the FSC, this study considers papers related to them that have focused on queuing theory. Some of these articles will be mentioned in the following paragraphs.

Nooteboom (1983) studied several similar shops, such as grocery stores, and through a theoretical interpretation based on queuing theory and some experimental evidence, found that costs and (in particular) labor depended on the size of the sales per grocery store. Halachmi et al. (2000) evaluated a robotic milking barn using a mathematical model based on a closed queuing network and studied factors such as cow queue length, cow waiting time, and equipment utilization.

Argent-Katwala and Bradley (2007) presented PEPA queues then studied individual customer behaviors and routing in queueing networks in a dairy shop. Ramadoss and Elango (2012) reviewed a queueing system in service facilities holding perishable inventory (e.g., meat in a slaughterhouse). They considered several factors, such as finite waiting space, having a single server, inventory (with maximum capacity S), and the exponential lifetime and exponential lead time of the procurement of items to minimize the entire service cost.

Iman and Borimnejad (2016) used queuing theory to analyze the quality of services among checkout operations in Refah chain stores (a grocery store chain in Iran). They found that several factors (e.g., store location, day of the week, time of day) can affect the efficiency of services. To reduce queuing waiting times within foodstuff logistics operations, Comi (2018) presented a method to help plan and manage delivery problems. He used the simulation approach and prototype tool to handle transport and logistics operator delivery.

IV. SEARCH STRATEGY AND SELECTION OF PAPERS

Our research was based on Google Scholar searches; Taylor; ACM Digital Library; EBSCO databases (Medline, Business Source Complete, Academic Search Complete); Elsevier and Springer journals (Science Direct, Medline, Inspec); and INFORMS publications, journals, and conference proceedings. The research strategy included two steps:

- **Query:** In this stage, digital libraries were searched. Articles were selected if the keyword ‘queuing’ had been used in the title, keywords, abstract, and/or in the modeling section of the article (but not just as a reference). Also, at least one of the keywords related to the FSC had been used in the title, keywords, abstract, and/or case study. Examples of such words are food, fruit, and vegetables, agriculture, horticultural crop, watermelon, rice, sugarcane, meat, chicken, edible fish, butter, oil, beverage, tea and coffee, restaurant, fast food, grocery store, milking (farm), dairy (shop), slaughterhouse, and perishable (including all food products that have a limited shelf life, such as fruits and vegetables, meat, and milk) had been used in the title, keywords, abstract and/or case study. Perishable products are not limited to perishable food products but also include products such as flowers and blood. This study only reviewed articles that involved perishable foods. To read more about the study of perishable products, we refer readers to the following articles: Melikov et al., 2016; Koroliuk et al., 2018; Diabat et al., 2019; Gitinavard et al., 2019; Yavari & Geraeli, 2019; Dutta & Shrivastava, 2020; Biuki et al., 2020.
- **Survey:** By reviewing the article's content, a relationship between queuing theory and FSC was identified. Based on this, articles were divided into two groups: (1) articles in which the queuing model and its application in the FSC were explained and (2) articles in which the queuing phenomenon is clearly related to one of the FSC issues.

By researching in the various valid outlets, such as journals and other publications outlets, 102 valid articles (indexed in JCR, Master Journal List, Scopus, DOAJ, PMC, or Medline) with the contribution of two issues of supply chain food and queuing theory (during the last 50 years) were found.

In addition to paying attention to the quality of the journals, we wanted to know which journals (and other publication outlets) include articles focused on the food industry and queuing theory together. As shown in *Fig. 2* (based on a descriptive analysis), more than three-fifths of papers were published in journals related to OR (including modeling, simulation, mathematics, engineering, computer, and management). One-fifth of articles have been published in specialized journals related to the food industry and related topics such as agriculture. The rest of the articles were found either in journals related to both OR and food industry fields or in journals focused on ecology and society. Also, it was determined that OR journals play a significant role in knowledge mobilization in this hybrid subject.

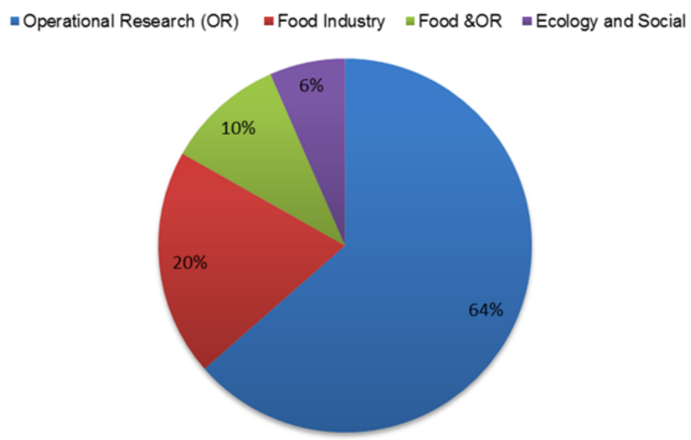

Fig. 2. The distribution of papers in journals

Fig. 3 (based on a descriptive analysis) indicates an increase in interest in research related to the subject of this study, with almost half of the articles having been published within the last ten years. This indicates that researchers have realized the importance of queuing theory in FSCM and have addressed this issue more intensely today than ever before.

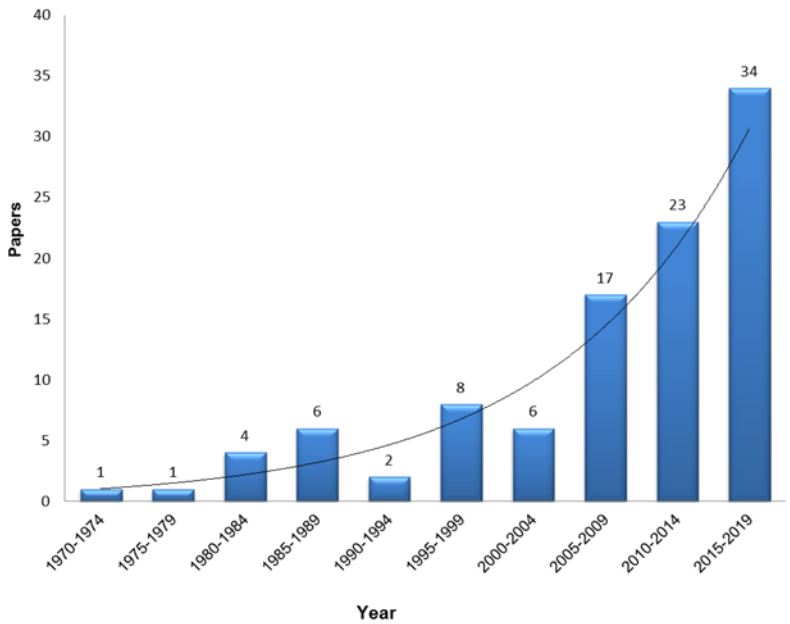

Fig. 3. The distribution of papers in five-year intervals

V. CLASSIFICATION METHODS

First, we consider the general framework of the FSC (from the first supplier to the last customer), for example, for the supply chain of fruits and vegetables (*Fig. 4*).

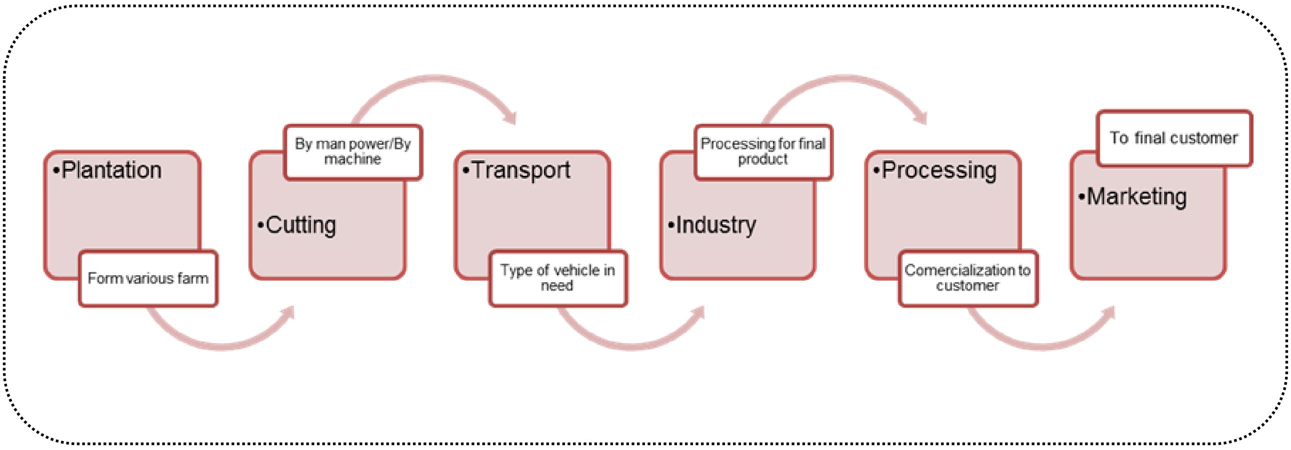

Fig. 4. Food processing supply chain management

The breadth of the FSC issue ("from farm to fork") has led to a wide range of articles with a variety of objectives and approaches in this area.

As an example, if we consider a restaurant as a node of these supply chains, this restaurant can be regarded as a customer in a study while also acting as a supplier for its customers in another study. As another example, if we consider the transportation system, any given vehicle can be viewed as a customer who should wait in the queue for loading, or it can be perceived as a server for product delivery to in-line customers. Such examples illustrate a significant challenge in classifying articles. The broad application of the queuing concept in articles and their different roles in each study complicates this challenge even further.

The articles were re-examined in a more general way from a different viewpoint to overcome these problems. Then an innovative grouping was proposed, in which the researcher's views were considered and, based on these views, the studies were divided into the three following main categories.

- **Food system design:** This category contains all studies focused on designing a food network or a food center. These papers generally include location, allocation, routing, layout and space, and demand distribution.
- **Food system support:** This category includes articles that prioritize resource planning to maximize system efficiency. Concerning the reviewed systems in each article, it is clear that resources (e.g., staff, vehicles, food, equipment) can vary.
- **Food system operation:** The last category includes articles that address the operational and detailed decisions (such as daily and weekly decisions) that are made within a system. Such findings include those related to managing waiting times and costs, customer behavior, queue length and capacity, customer arrival and departure rates, queue discipline, safety, and product and service quality.

We believe that with these proposed categories, we can provide comprehensive coverage of the application of queuing theory in the examined papers.

Table II shows each of the categories and its related subcategories.

Table II. Classification of articles into main categories and their subcategories (QTA on FSCM)

Food System Design	*Food System Support*	*Food System Operation*
1- Location 2- Allocation 3- Routing 4- Layout and Space 5- Demand distribution	1- Staff management 2- Vehicles management 3- Food management 4- Equipment management	1- Waiting time management 2- Cost management 3- Customer behavior 4- Queue length and Capacity 5-Arrival rate and Service rate 6- Queue discipline 7- Safety and Product and Service quality

Articles will be summarized and classified in each category and its subcategories. For this purpose, the following sections are presented in tables. For each article, the main characteristics, its field of activity, relevant subcategory, and approach (determining the relationship between FSCs and queuing theory) are presented separately. Articles are arranged in tables ascendingly by date.

To summarize the tables' text in the following sections, we consider a code for each of the classifications mentioned above (see Table III). In this notation, subcategories are used as indexes alongside the codes (for example, D_2 represents the "*Food System Design*" main category and the "*Allocation*" subcategory).

Table III. The categories' code

Classifications	*Code*
Food System *Design*	D
Food System *Support*	S
Food System *Operation*	O

Tables A.I, A.II, and A.III introduce the details of the food system design, support, and operation category in the appendix of this paper.

VI. RESULT OF CONTENT ANALYSES

This section discusses the primary results of this study to highlight the prominent research gaps and promising research opportunities in the QTA and FSCM hybrid issue literature. The analyses are presented based on the following five perspectives: food supply chain management, decision level, type of food product, queuing system, and modeling methodology.

A. Food supply chain management

Concerning *Fig. 5*, fewer studies have been carried out during the last 50 years in the fields of farms, slaughterhouses, food hubs, plants, and warehouses.

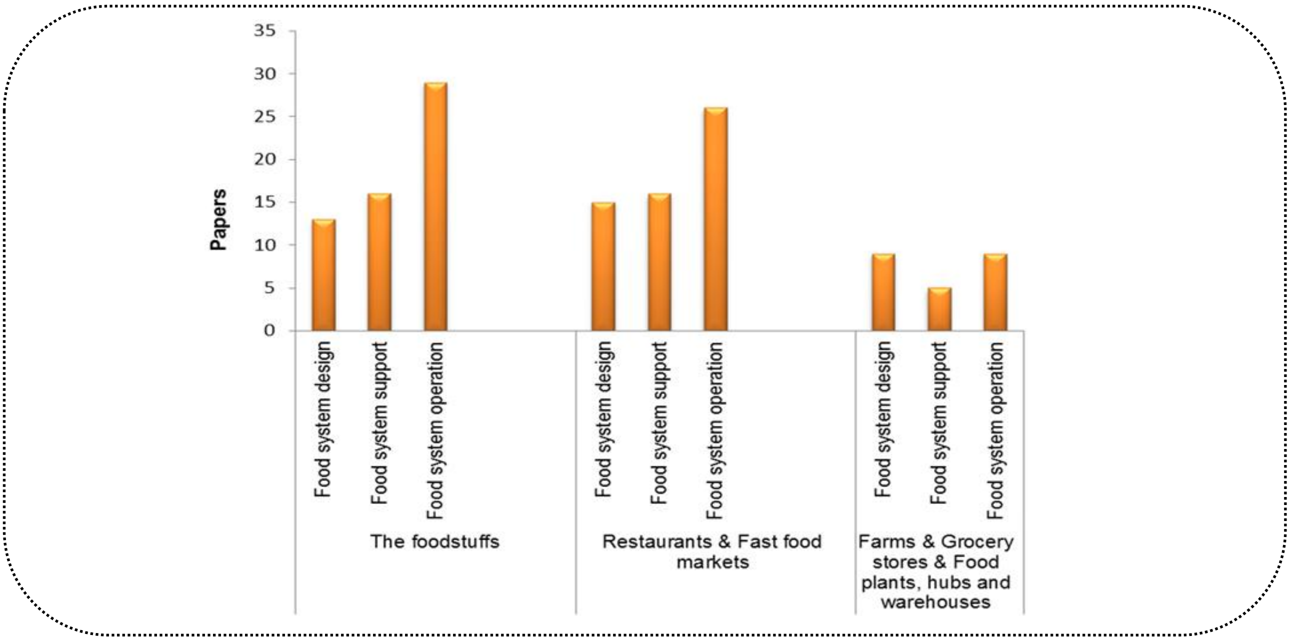

Fig. 5. The distribution of papers in each of the predefined groups of FSC

According to Tables A.I, A.II, and A.III, most articles are related to centers of production, distribution, and storage of food-related to grocery stores (supermarkets). The queuing theory has often been used for centers with individual and daily customers, such as grocery stores and restaurants. In contrast, applying this theory about location issues and allocation of the food mentioned above centers can be very efficient, especially for perishable food products. Meanwhile, attention to the transportation system and routing operation with the queuing theory approach is exciting and essential because most of these centers have a significant distance from their customers. It is vital to maintain the quality and safety of food products.

B. Decision level

Fig. 6 shows that most of the evaluated articles focused on operational and short-term decisions. Meanwhile, using the concept of queues in strategic decisions (such as those related to location and allocation) and tactical decisions (such as those involving the planning of the quantity of transport fleet and the quantity of the food as a source for food centers) have been considered relatively little by researchers. Of course, among the subcategories of the food system operation group, little attention has been paid to cost (as the main subject of the paper and not only as an objective function).

In recent years, especially over the last five years, authors have focused heavily on the shortcomings above. They have significantly benefited from the theory of queues for the strategic and tactical planning of production, distribution, storage, and transportation of raw and cooked foodstuffs “from farm to fork” (see *Fig. 7*).

C. Applying queuing theory to a particular food product

In this section, we analyze the reviewed papers from the perspective of product type. *Fig. 8* shows different types of food products considered in the collected papers. It was observed that queuing theory has little use in beverages (one paper), cereals (three papers), and protein products (six papers). Also, in the case of dairy products, although they are highly perishable and queuing theory is perhaps the best option for this type of product, little research has been done in this area. In some of the papers related to perishable products, the issue of food is addressed – in some of these, even the exact name of the product is mentioned (e.g., milk, meat). However, due to the importance of this product category, we have counted the related papers separately.

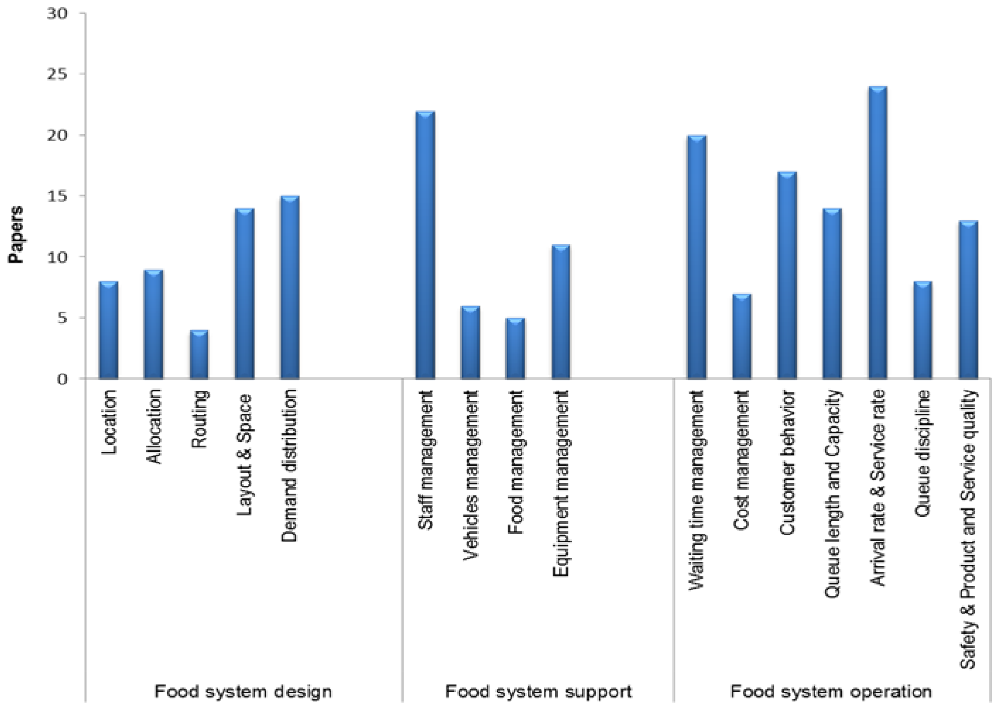

Fig. 6. The distribution of papers in each predefined subcategory

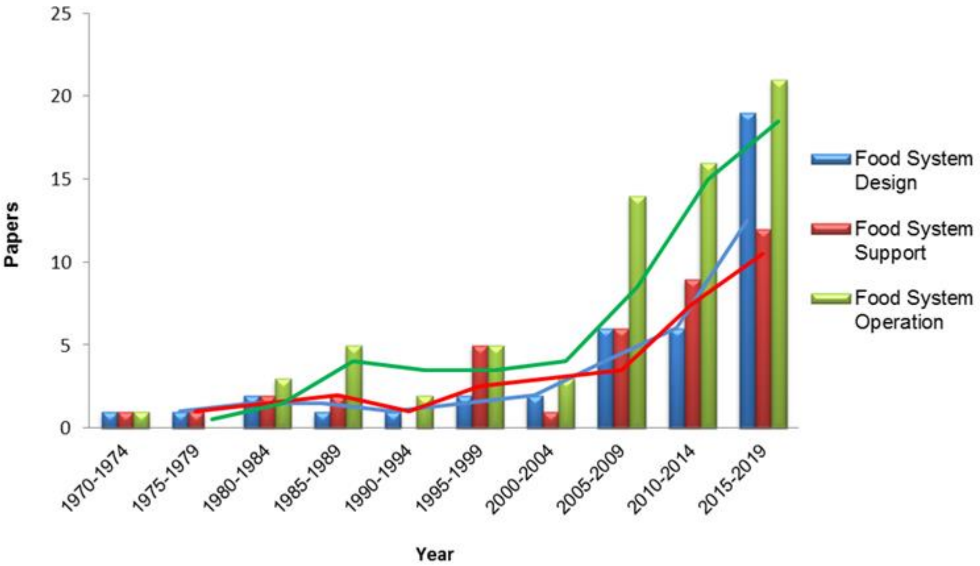

Fig. 7. The distribution of papers within each predefined category (in five-year intervals)

In general, it can be concluded that queuing theory has not yet been considered by researchers despite the tremendous impact it can have on a particular food system (e.g., protein and dairy products).

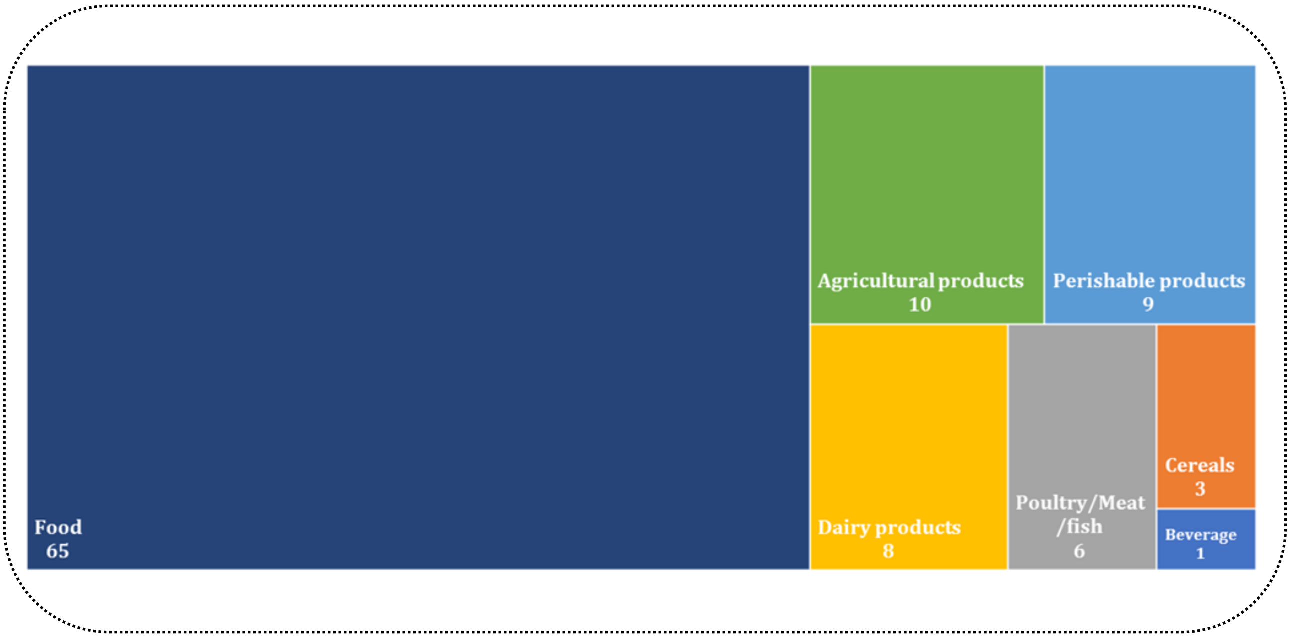

Fig. 8. The distribution of the reviewed papers according to the product type

D. Perspective on queuing systems

In this section, we analyze the collected papers focusing on different dimensions of queuing theory (see *Fig. 9*). Some of the reviewed papers optimize or analyze the queue parameters described earlier in Section II.A, while others evaluate the system using queue evaluation criteria (including waiting time, queue length, and system idle time (as percentages)). In some papers, the queuing system did not play a pivotal role, and the researcher's main focus was on another topic. The results show that most previous research works have dealt with the issues of arrival and service rate (24 papers), the number of servers (21 papers), and waiting times (20 papers). Meanwhile, few studies have assessed population size (six papers) and queue discipline (eight papers). Also, none of the articles considered the evaluation criteria of system idle time.

The analysis results of this section are listed in Table A.III (for each paper separately in the third column). The papers on the number of servers are presented in Table A.II (entitled S_1).

E. Modeling methodology

Modeling, simulation, and optimization are related to computer systems that play an essential role in science and engineering today, and they help engineers reduce the cost and amount of time spent on research. In this section, at first, modeling, optimization, and simulation are introduced. Then, using content analysis, articles are categorized based on the used modeling methodology, and finally, the gaps in this field are introduced.

Modeling creates a "model" representing an object or system either with all or with a subset of its properties. A model can be precisely the same as the original system or approximate it (Razzaghi, 2003). People always use modeling to make decisions in their daily lives, though usually not formally. There are five types of models: verbal, schematic, iconic, physical, and mathematical (Alvani, 2016). Simulation and optimization are both subsets of modeling, and they usually use the same computational techniques and algorithms. However, they are different activities. Each method (simulation and optimization) has its advantages and disadvantages, and so different techniques are more suitable for different types of issues. Some key differences are as follows (MOSIMTEC, 2020).

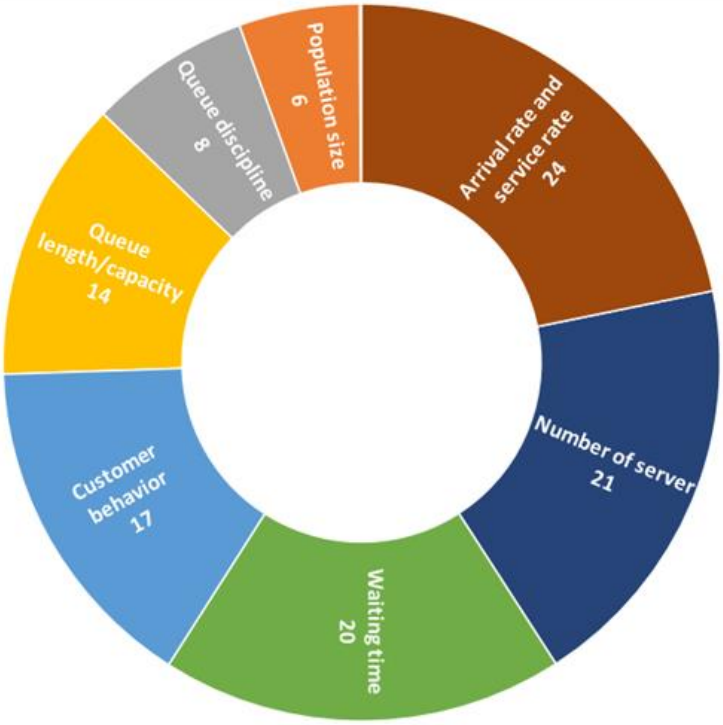

Fig. 9. The distribution of the reviewed papers according to the queue parameters

"What-if" analysis: The simulation is more suitable for observing the performance of the simulated system by manipulating initial conditions (i.e., the values of the input variables). Usually, optimization is used to determine the optimal system design.

Constraints: The success of optimization depends significantly on the application of constraints to the problem parameters. During a simulation, the analyst starts with a real initial value and then modifies this value within a reasonable range to observe changes in the outputs.

Influence of randomness: Simulations are more flexible against various random parameters, although this variation can make a big difference in the accuracy of the results. However, optimization accurately identifies mathematical relationships that do not vary.

Planning and decision support: In optimization, the best unique answer to a particular problem is provided. For this reason, optimization is the best way to support tactical and strategic planning. This is one of the most important advantages of optimization. In contrast, simulation is considered more exploratory. *Modeling difficulty:* Optimization modeling is more complex than simulation modeling. In addition to the need for more assumptions about inputs, optimization modeling requires a robust solution method to produce the optimal solution.

It should be noted that by "modeling," we mean models that are not the optimization and simulation type, such as prediction models, equilibrium models, growth models, transition models.

We found that many articles have not used specific modeling during the literature review but instead analyzed the system. Analytical articles in this study included the papers that did the following: (a) compared two or more queuing systems; (b) analyzed the queuing system using presentation of the theorem and lemma; (c) analyzed case studies and different scenarios; (d) controlled a queuing system; and (e) those that focused on statistical analyses.

In addition, in some articles several methodologies have been used. Therefore, based on the applied modeling methodology, the papers were classified into the following twelve categories: {Modeling}; {Optimization}; {Simulation}; {Analysis}; {Optimization, Analysis}; {Optimization, Simulation}; {Optimization, Modeling}; {Simulation, Analysis}; {Modeling, Analysis}; {Modeling, Simulation}; {Optimization, Simulation, Analysis}; and {Simulation, Modeling, Analysis}.

Table IV shows the classification of the reviewed articles based on the modeling methodology.

To better analyze the articles, they were sorted in two ways (see *Fig. 10* and *Fig. 11*). It can be observed from *Fig. 10* that most researchers have used only one method in their studies, and there are very few articles focusing on multi methodologies. However, each method of general modeling, optimization, simulation, and analysis has its advantages, and the simultaneous use of these methods can significantly increase the efficiency of the study.

Table IV. Classification of papers based on modeling methodology

Modeling methodology	***Papers***
Optimization	(Mesterton-Gibbons, 1988), (Lan et al., 2005), (Halachmi, 2007), (Liao, 2007a and 2007b), (Wagner et al., 2009), (Hwang et al., 2010), (Patel et al., 2012), (Satheesh Kumar & Elango, 2012), (Koh et al., 2014), (Aggarwal et al., 2014), (Mahmoodi et al., 2015), (Kathirvel et al., 2017), (Hanukov et al., 2017), (Lee et al., 2017), (Saeedi et al., 2019)
Modeling	(Bart, 1982), (Patterson, 1995), (Beyer, 1998), (Blanckenhorn et al., 1998), (Nahmias et al., 2004), (Mullowney & James, 2007)
Simulation	(Parkan, 1987), (Parkan, 1988), (Ridgley,1989), (Farahmand & Martinez, 1996), (Sharan & Madhavan, 1999), (Church & Newman, 2000), (Sayeed et al., 2006), (Osborne & Duffin, 2007), (Chou & Liu, 2008), (Oliveira et al., 2012), (Muslu et al., 2014), (Jain & Ali, 2016), (Roy et al. 2016), (Weng et al., 2016), (Rabbani & Dolatkhah, 2017), (Rodrigues et al., 2018), (Comi et al., 2018)
Analysis	(W. Whitney & Cochran, 1976), (Graves, 1982), (Seeley, 1989), (Goh et al., 1993), (Pruyn & Smidts, 1993), (O'Laughlin, 1996), (Thompson, 1998), (Batabyal & Yoo, 2006), (Luczak & McDiarmid, 2006), (Ljungberg et al., 2007), (Chen, 2008), (Raz & Ert, 2008), (Dharmawirya & Adi, 2011), (Battini et al., 2014), (Lim et al., 2014), (Morejón & Coronel, 2014), (Prasad et al., 2015), (Nehzati et al., 2015), (Austria, 2015), (Ding et al., 2014), (Iman & Borimnejad, 2016), (Koroliuk et al., 2017), (Dubosson et al., 2017), (Inman & Nikolova, 2017), (Gumus et al., 2017), (Gao et al., 2018), (de Oliveira & Keeling, 2018), (Weiss & Tucker, 2018)
Optimization & Analysis	(Li & Wang, 2010), (Raman & Roy, 2015)
Modeling & Analysis	(Nooteboom, 1983), (Halachmi et al., 2000), (Argent-Katwala & Bradley, 2007), (Ke et al., 2012), (Sanctis et al., 2014), (Hanukov et al., 2019)
Simulation & Analysis	(Landauer, 1984), (Field et al., 1997), (Kleijnen et al., 2001), (De Vries et al., 2018)
Optimization & Simulation	(Wyman & Orr, 1973), (Halachmi, 2004), (Analoui & Jamali, 2008), (Halachmi, 2012), (Halachmi, 2013), (Venkatadri et al., 2014), (Mouhaffel et al., 2016), (Boywitz & Boysen, 2018)
Modeling & Simulation	(Evers, 2004), (Ledauphin et al., 2006), (Nichols et al., 2011), (Palkova et al., 2012), (Ampatzidis et al., 2014), (Mittal & X Krejci, 2017), (Yang, 2018)
Optimization & Modeling	(Juliano, 1989), (Wirtz, 2012)
Simulation & Modeling & Analysis	(van 't Ooster et al., 2012), (Abulah, 2013), (Zhang et al., 2019)
Optimization & Simulation & Analysis	(Tanizaki & Shimmura, 2017), (Kaid et al., 2018)

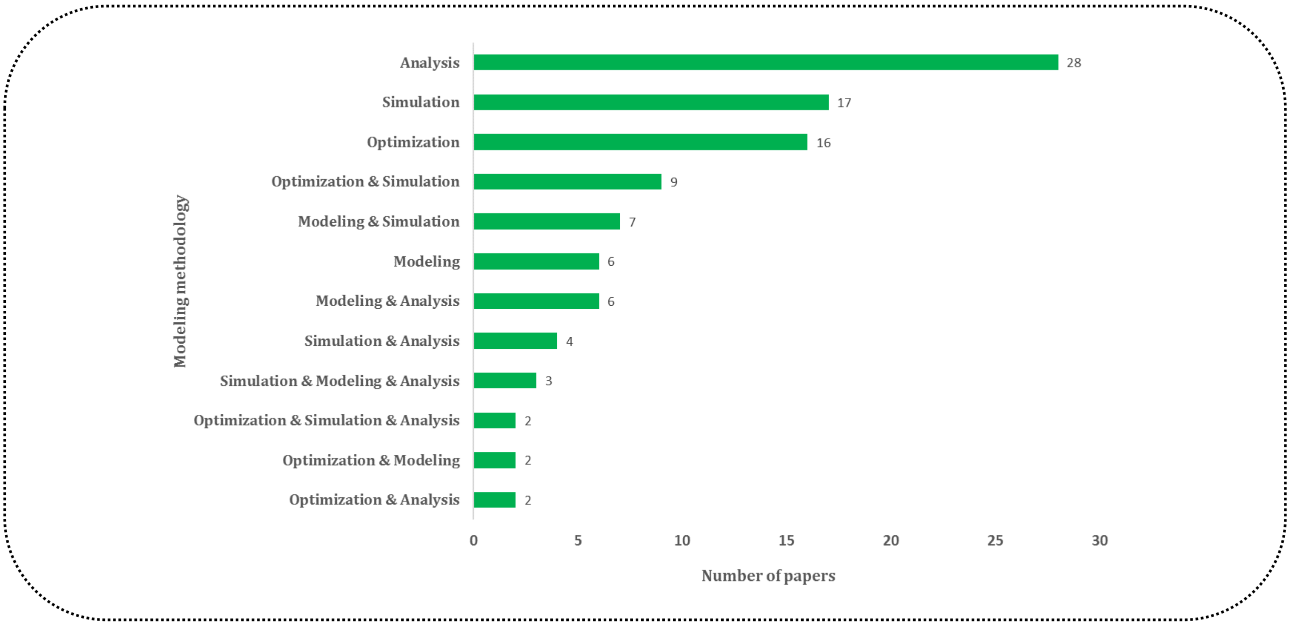

Fig. 10. The distribution of the reviewed papers according to the modeling methodology

In *Fig. 11*, the selected papers are sorted separately over ten-year periods. As can be seen, the application of only one methodology (especially in optimization, simulation, and analysis) has increased logarithmically. As we move from 1970 to 2019, we find that the authors have realized the importance of combining methodologies and have used this approach more than before. For example, the following combinations have only been used in the last ten years: {optimization, analysis}; {optimization, simulation, analysis}; and {simulation, modeling, analysis}. Besides, the combinations of {optimization, simulation} and {modeling, simulation} have only been used in the last twenty years. However, it should be noted that there is only one study that employs a combination of {optimization, simulation} in the 1970s. In general, the optimization methodology and analysis are rarely used simultaneously with other methods. Instead, the simulation methodology has usually been used with other methodologies.

Therefore, from the discussions mentioned above, it can be concluded that there are wide gaps related to the simultaneous application of various modeling methodologies.

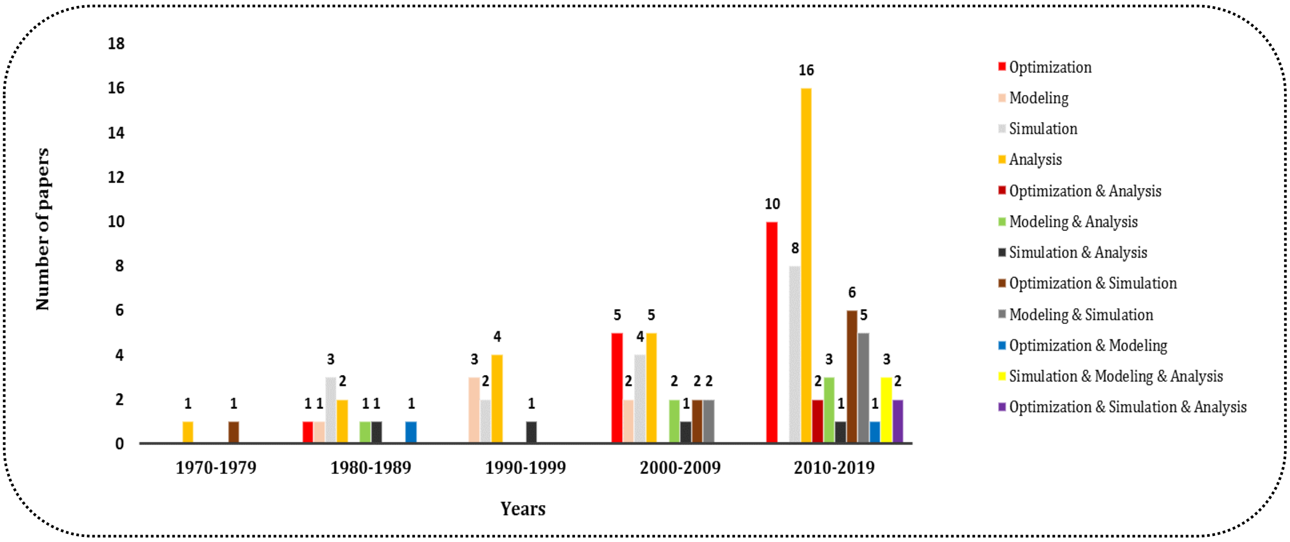

Fig. 11. The distribution of the reviewed papers according to the modeling methodology (over 10-year periods)

VII. CONCLUSION

In the current study, we fill a gap in the literature by presenting a systematic review of previous studies on the application of queuing theory on FSCM and exploring prominent research gaps. We investigated related reviewed articles from 1982 to 2020, and none of them specifically addressed the subject of QTA on FSCM. To achieve the present study's aim, we searched valid outlets (JCR, Master Journal List, Scopus, DOAJ, PMC, and Medline) and found 102 articles published between 1970 and 2019 that have considered queue concepts in planning and improving the performance of food systems.

Due to the variety of strategies used in each article and their activity field, the categorization of articles was not a simple matter. Therefore, to conduct a useful review, we investigated the articles from the perspective of the article authors based on innovative content analysis and according to the main approach of each article. Then, we classified the articles into three main categories: "food system design," "food system support," and "food system operation." Then, we considered subcategories for each category. In this way, we were able to provide a comprehensive overview of all selected articles.

We also performed additional content and descriptive analyses to identify FSCM and QTA trends in the collected research. All analyses were performed accurately, honestly, and fairly. The results of our analyses were presented based on the following five perspectives: FCSM, decision level, type of food product, queuing system, and modeling methodology. Meanwhile, to make this article more practical as a guideline, we briefly described each article in relevant tables.

The following points summarize the results based on the descriptive and content analyses raised during the study. The below points are presented in the order in which they appear in this article.

- More than half of the articles (approximately 56%) published during the fifty years were published in the last ten years. This indicates that researchers have recently realized the importance of queuing theory in the management of FSC and have addressed this issue more today than ever before.
- Among the peer-reviewed journals that have published relevant articles, OR journals have played the most prominent role in spreading this issue. Although food industry journals do not have the smallest share in this regard, it seems that they are not adequately acquainted with this issue.
- Due to the dispersion of articles in the field of FSC, the collected articles were classified into the following three categories: (a) foodstuffs; (b) restaurants, fast food markets, and catering companies; and (c) farms, grocery stores, food plants, hubs, and warehouses. Our research shows that queuing theory has been considered very little in the third category compared to the other two. Most importantly, most of the articles in this category are related to supermarkets and grocery stores. The queuing theory has often been used for centers that have individual and daily customers. Therefore, it can be concluded that there is a wide gap in the application of queuing theory in other food centers (e.g., farms, factories, hubs, warehouses, and distribution centers). Meanwhile, the transportation system and routing operation within queuing theory are fascinating because most centers are a significant distance from their customers.
- Most of the collected articles focused on operational and short-term decisions. Meanwhile, the queue concept seemed to be lacking in strategic decisions (such as those related to location and allocation) and tactical decisions (such as those related to the planning of the quantity of transport fleet and the quantity of the food as a source for food centers). In recent years – especially in the last five years – researchers have focused on the shortcomings above. They have significantly benefited from applying the theory of queues to strategic and tactical planning in the following scopes: production, distribution, storage, and transportation of raw and cooked foodstuffs.
- Our review shows that queuing theory has the least use concerning beverages (one paper), cereals (three papers), and protein products (six papers). Also, in the case of dairy products, although they are highly perishable and queuing theory is perhaps the best option for them, little research has been done in this area (eight papers).

- Relatively large numbers of the collected researches dealt with the topics of arrival and service rate (24 papers), the number of servers (21 papers), and waiting times (20 papers). Few studies considered population size (six papers) and the queue discipline (eight papers). Also, none of the articles used the evaluation criteria of system idle time.
- In this study, based on the applied modeling methodology, the papers were classified into the following twelve categories: {Modeling}; {Optimization}; {Simulation}; {Analysis}; {Optimization, Analysis}; {Optimization, Simulation}; {Optimization, Modeling}; {Simulation, Analysis}; {Modeling, Analysis}; {Modeling, Simulation}; {Optimization, Simulation, Analysis}; and {Simulation, Modeling, Analysis}. Usually, researchers have used only one method in their studies, and there are very few articles focusing on multi methodologies. As we moved from 1970 to 2019, we found that the authors have realized the importance of combining methodologies and have used this approach more than before. However, there are wide gaps related to the simultaneous application of various modeling methodologies.

Some suggestions for topics to be covered in future research are as follows:

- ✓ Determining the line of trucks that should be loaded in the food hub or factory
- ✓ Determining the queue of goods that should be opened and packaged by operators in food hubs or warehouses
- ✓ Determining the amount of cooling equipment and their optimal allocation to various warehouse spaces in terms of food waiting lines
- ✓ Planning animal waiting lines in stables to ensure proper nutrition and hygiene
- ✓ Considering the arrival and service rates of customers in the queues of farms, the quality of fruits and vegetables is maintained.
- ✓ Budgeting a dairy plant considering waiting costs
- ✓ Planning for the fair supply and demand of food government companies for customers in waiting lines
- ✓ Evaluating the arrival and digestion rate of food in the gut/ stomach to prevent gastrointestinal disease
- ✓ The use of queuing systems in the supply chain of special foods such as dairy products, meat, beverages, and cereals is recommended.
- ✓ The simultaneous use of various modeling methodologies is suggested to increase the achievements of the study.
- ✓ Due to the lack of articles focusing on queue discipline, unconventional but efficient disciplines such as priority discipline are recommended.

Finally, we emphasize that this study cannot claim exhaustive, though it can serve as a guideline to provide reasonable insights for researchers and readers interested in this field.

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REFERENCES

Abulah, T. A. (2013). Modeling and evaluation of queuing system. *Journal of Babylon University/Pure and Applied Sciences*, *21*(3), 797- 803.

Adamczuk, G., & Lindau, L. (2012). A framework for delivery scheduling in the poultry industry. *Journal of Scheduling*, *15*(6), 757-772. https://doi.org/10.1007/s10951-012-0267-z

Aggarwal, A., Singh, V., & Kumar, S. (2014). Availability analysis and performance optimization of a butter oil production system: a case study. *International Journal of System Assurance Engineering and Management*, *8,* 1-17. https://doi.org/10.1007/s13198-014-0310-x

Akkerman, R., Farahani, P., & Grunow, M. (2010). Quality, safety and sustainability in food distribution: A review of quantitative operations management approaches and challenges. *Operations Research-Spektrum*, *32*, 863-904. https://doi.org/10.1007/s00291-010-0223-2

Alvani, S. M. (2016). *public policy-making*. (2th ed.). Iran: Tehran. (In Persian).

Ampatzidis, Y. G., Vougioukas, S. G., Whiting, M. D., & Zhang, Q. (2014). Applying the machine repair model to improve efficiency of harvesting fruit. *Biosystems Engineering*, *120*, 25-33. https://doi.org/https://doi.org/10.1016/j.biosystemseng.2013.07.011

Analoui, M., & Jamali, S. (2008). Congestion Control in the Internet: Inspiration from Balanced Food Chains in the Nature. *J. Network Syst. Manage.*, *16*, 1-10. https://doi.org/10.1007/s10922-007-9093-6

Argent-Katwala, A., & Bradley, J. (2007). PEPA Queues: Capturing Customer Behaviour in Queueing Networks. *Electr. Notes Theor. Comput. Sci.*, *190*, 3-25. https://doi.org/10.1016/j.entcs.2007.07.002

Audsley, E., & Sandars, D. (2009). A review of the practice and achievements from 50 years of applying OR to agricultural systems in Britain. *OR Insight*, *22*, 2-18. https://doi.org/10.1057/ori.2008.1

Austria, L. A. (2015). Queue Management Practices of Quick ServiceRestaurants (QSR) in Lipa City, Philippines *Asia Pacific Journal of Multidisciplinary Research*, *3*(5), 87-95.

Bart, N. (1982). A new theory of retailing costs. *European Economic Review*, *17*(2), 163-186.

Batabyal, A. A., & Yoo, S. J. (2006). A complete characterization of mean waits times for citizens in the non-preemptive corruption regime. *Applied Economics Letters*, *13*(12), 759-762.

Battini, M., Vieira, A., Barbieri, S., Ajuda, I., Stilwell, G., & Mattiello, S. (2014). Invited review: Animal-based indicators for on-farm welfare assessment for dairy goats. *Journal of Dairy Science*, *97*(11), 6625-6648. https://doi.org/https://doi.org/10.3168/jds.2013-7493

Behzadi, G., O'Sullivan, M., Olsen, T., & Zhang, A. (2017). Agribusiness Supply Chain Risk Management: A Review of Quantitative Decision Models. *Omega*. https://doi.org/10.1016/j.omega.2017.07.005

Beske, P., Land, A., & Seuring, S. (2014). Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature. *International Journal of Production Economics*, *152*, 131-143. https://doi.org/https://doi.org/10.1016/j.ijpe.2013.12.026

Beyer, J. E. (1998). Stochastic stomach theory of fish: an introduction. *Ecological Modelling*, *114*(1), 71-93. https://doi.org/https://doi.org/10.1016/S0304-3800(98)00128-8

Bhagat, D., & Dhar, U. R. (2011). Agriculture Supply Chain Management: A Review. *IUP Journal of Supply Chain Management*, *8*(3), 7-25.

Biuki, M., Kazemi, A., & Alinezhad, A. (2020). An integrated location-routing-inventory model for sustainable design of a perishable products supply chain network. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.120842

Blanckenhorn, W., Grant, J., & Fairbairn, D. (1998). Monopolization in a resource queue: Water striders competing for food and mates. *Behav. Ecol. Sociobiol.*, *42*, 63-70. https://doi.org/10.1007/s002650050412

Borodin, V., Bourtembourg, J., Hnaien, F., & Labadie, N. (2016). Handling uncertainty in agricultural supply chain management: A state of the art. *European Journal of Operational Research*, *254*. https://doi.org/10.1016/j.ejor.2016.03.057

Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*, *33*(1), 32-48. https://doi.org/https://doi.org/10.1016/j.foodcont.2013.02.004

Boywitz, D., & Boysen, N. (2018). Robust storage assignment in stack- and queue-based storage systems. *Computers & Operations Research*, *100*, 189-200. https://doi.org/https://doi.org/10.1016/j.cor.2018.07.014

Churchman, C. W., Ackoff, R. L., & Arnoff, E. L. (1957). *Introduction to Operations Research.* Wiley.

Chen, S.-P. (2008). Evaluating performance of flow line systems with blocking under fuzzy environments. *Cybernetics and Systems, 40* (1), 33-51.

Chou, C.-Y., & Liu, H.-R. (2008). Simulation study on the queuing system in a fast-food restaurant. *Journal of Restaurant & Foodservice Marketing*, *3*(2), 23-36.

Church, I., & Newman, A. (2000). Using simulations in the optimisation of fast food service delivery. *British Food Journal*, *102,* 398-405. https://doi.org/10.1108/00070700010329308

Comi, A., Schiraldi, M. M., & Buttarazzi, B. (2018). Smart urban freight transport: tools for planning and optimising delivery operations. *Simulation Modelling Practice and Theory*, *88,* 48-61. https://doi.org/https://doi.org/10.1016/j.simpat.2018.08.006

Cooper, M., & Ellram, L. (1993). Characteristics of Supply Chain Management & the Implications for Purchasing & Logistics Strategy. *International Journal of Logistics Management, The*, *4,* 13-24. https://doi.org/10.1108/09574099310804957

Cooper, R. B. (1980). *Introduction to Queuing Theory* (2nd ed.). Elsevier North Holland.

Dania, W. A. P., Xing, K., & Amer, Y. (2018). Collaboration behavioural factors for sustainable agri-food supply chains: A systematic review. *Journal of Cleaner Production*, *186*. https://doi.org/10.1016/j.jclepro.2018.03.148

de Oliveira, D., & Keeling, L. (2018). Routine activities and emotion in the life of dairy cows: Integrating body language into an affective state framework. *PLOS ONE, 13,* e0195674. https://doi.org/10.1371/journal.pone.0195674

De Vries, J., Roy, D., & De Koster, R. (2018). Worth the wait? How restaurant waiting time influences customer behavior and revenue. *Journal of Operations Management, 63,* 59-78.

Dharmawirya, M., & Adi, E. (2011). Case Study for Restaurant Queuing Model. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2014470

Diabat, A., Jabbarzadeh, A., & Khosrojerdi, A. (2019). A perishable product supply chain network design problem with reliability and disruption considerations. *International Journal of Production Economics*, *212*, 125-138. https://doi.org/https://doi.org/10.1016/j.ijpe.2018.09.018

Diaz Allegue, L., Puyol, D., & Melero, J. (2020). Food waste valorization by purple phototrophic bacteria and anaerobic digestion after thermal hydrolysis. *Biomass and Bioenergy*, *142,* 105803. https://doi.org/10.1016/j.biombioe.2020.105803

Ding, D., Ou, J., & Ang, J. (2014). Analysis of ticket queues with reneging customers. *Journal of the Operational Research Society, 66,* 231-246. https://doi.org/10.1057/jors.2013.185

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. *Journal of Cleaner Production*, *142,* 1119-1130. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.03.117

Dubosson, M., Fragnière, E., Junod, N., & Willaerts, B. (2018). Detecting Customer Queue "at-risk" Behaviors Based on Ethograms to Minimize Overall Service Dissatisfaction. In (pp. 18-29). https://doi.org/10.1007/978-3-319-91764-1_2

Dutta, P., & Shrivastava, H. (2020). The design and planning of an integrated supply chain for perishable products under uncertainties: A case study in milk industry. *Journal of Modelling in Management, ahead-of-print*. https://doi.org/10.1108/JM2-03-2019-0071

Evers, E. (2004). Predicted quantitative effect of logistic slaughter on microbial prevalence. *Preventive veterinary medicine*, *65,* 31-46. https://doi.org/10.1016/j.prevetmed.2004.06.008

FAO. (2013). *Livestock and Landscapes*. http://www.fao.org/3/ar591e/ar591e.pdf

FAO, IFAD, UNICEF, WFP, & WHO. (2018). *The State of Food Security and Nutrition in the World 2018: Building climate resilience for food security and nutrition*. https://www.who.int/nutrition/publications/foodsecurity/state-food-security-nutrition-2018-en.pdf?ua=1

Farahmand, K., & Martinez, A. F. G. (1996). Simulation and animation of the operation of a fast food restaurant. Proceedings Winter Simulation Conference, Coronado, California, USA.

Field, A., McKnew, M., & Kiessler, P. (1997). A simulation comparison of buffet restaurants: Applying monte carlo modeling. *The Cornell Hotel and Restaurant Administration Quarterly*, *38*(6), 5-79. https://doi.org/https://doi.org/10.1016/S0010-8804(97)85372-4

Frijda, N. H. (1967). Problems of computer simulation. *Behavioral Science*, *12*(1), 59-67.

Ganeshkumar, C., Pachayappan, M., Madanmohan, G., (2017). Agri-food Supply Chain Management: Literature Review. Intelligent Information Management, 2017, 68-96. https://doi.org/10.4236/iim.2017.92004

Gao, D., Chen, J., & Wang, Y. (2018). *Study on Omnichannel Service for Time-Sensitive and Price-Sensitive Demand*. https://doi.org/10.1109/ICSSSM.2018.8465076

Ghaleb, M., Suryahatmaja, U., & Al-Harkan, I. (2015). *Modeling and Simulation of Queuing Systems Using Arena Software: A Case Study*. https://doi.org/10.1109/IEOM.2015.7093945

Gitinavard, H., Ghodsypour, S. H., & Akbarpour Shirazi, M. (2019). A bi-objective multi-echelon supply chain model with Pareto optimal points evaluation for perishable products under uncertainty [Article]. *SCIENTIA IRANICA*, *26*(5 (Transactions E: Industrial Engineering)), 2952-2970. https://www.sid.ir/en/journal/ViewPaper.aspx?ID=692480

Glen, J. J. (1987). Feature Article—Mathematical Models in Farm Planning: A Survey. *Operations Research*, *35*(5), 641-666.

Goh, C.-H., Greenberg, B. S., & Matsuo, H. (1993). Perishable inventory systems with batch demand and arrivals. *Operations Research Letters*, *13*(1), 1-8. https://doi.org/https://doi.org/10.1016/0167-6377(93)90076-S

Graves, S. C. (1982). The application of queueing theory to continuous perishable inventory systems. *Management Science*, *28 (4)*, 400- 406.

Gumus, S., Bubou, G., & Oladeinde, M. (2017). Application of queuing theory to a fast food outfit: a study of blue meadows restaurant. *Independent Journal of Management & Production*, *8*, 441. https://doi.org/10.14807/ijmp.v8i2.576

Halachmi, I. (2004). Designing the Automatic Milking Farm in a Hot Climate. *Journal of Dairy Science*, *87*, 764-775. https://doi.org/10.3168/jds.S0022-0302(04)73220-8

Halachmi, I. (2007). Biomass management in recirculating aquaculture systems using queuing networks. *Aquaculture*, *262*(2), 514-520. https://doi.org/https://doi.org/10.1016/j.aquaculture.2006.10.015

Halachmi, I. (2012). Mathematical principles of production management and robust layout design: Part I. 250-ton/year recirculating aquaculture system (RAS). *Aquacultural Engineering*, *50*, 1-10. https://doi.org/https://doi.org/10.1016/j.aquaeng.2012.03.001

Halachmi, I. (2013). Mathematical principles of production management and robust layout design: Part III. 2500-ton/year fish farming in marine net cages. *Aquacultural Engineering*, *54*, 110-117. https://doi.org/https://doi.org/10.1016/j.aquaeng.2012.11.001

Halachmi, I., Adan, I., Wal, J., Beek, P., & Heesterbeek, J. A. P. (2003). Designing the optimal robotic milking barn by applying a queuing network approach. *Agricultural Systems*, 681-696. https://doi.org/10.1016/S0308-521X(02)00086-0

Halachmi, I., Adan, I. J. B. F., van der Wal, J., Heesterbeek, J. A. P., & van Beek, P. (2000). The design of robotic dairy barns using closed queueing networks. *European Journal of Operational Research*, *124*(3), 437-446. https://doi.org/https://doi.org/10.1016/S0377-2217(99)00312-4

Hanukov, G., Avinadav, T., Chernonog, T., Spiegel, U., & Yechiali, U. (2017). A queueing system with decomposed service and inventoried preliminary services. *Applied Mathematical Modelling*, *47*, 276-293. https://doi.org/https://doi.org/10.1016/j.apm.2017.03.008

Hanukov, G., Avinadav, T., Chernonog, T., & Yechiali, U. (2019). Performance improvement of a service system via stocking perishable preliminary services. *European Journal of Operational Research, 274 (3),* 1000- 1011.

Hardaker, J. B., Pandey, S., & Patten, L. H. (1991). Farm Planning under Uncertainty: A Review of Alternative Programming Models. *Review of Marketing and Agricultural Economics*, *59*, 1-14.

Hayashi, K. (2000). Multicriteria analysis for agricultural resource management: A critical survey and future perspectives. *European Journal of Operational Research*, *122*, 486-500. https://doi.org/10.1016/S0377-2217(99)00249-0

Higgins, A., Miller, C., Archer, A., Ton, T., Fletcher, C., & McAllister, R. (2010). Challenges of operations research practice in agricultural value chains. *JORS*, *61*, 964-973. https://doi.org/10.1057/jors.2009.57

Hwang, J., Gao, L., & Jang, W. (2010). Joint demand and capacity management in a restaurant system. *European Journal of Operational Research*, *207*, 465-472. https://doi.org/10.1016/j.ejor.2010.04.001

Iman, R., & Borimnejad, V. (2016). Analysis of quality of services for checkout operation in Refah chain stores using queuing theory. *Journal of Foodservice Business Research*, *20*, 1-10. https://doi.org/10.1080/15378020.2016.1192891

Inman, J., & Nikolova, H. (2017). Shopper-Facing Retail Technology: A Retailer Adoption Decision Framework Incorporating Shopper Attitudes and Privacy Concerns. *Journal of Retailing*. https://doi.org/10.1016/j.jretai.2016.12.006

Jain, P., & Ali, R. (2016). A case study of take away restaurant using simulation modelling approach. *Journal of Service Science Research*, *8*, 207-221. https://doi.org/10.1007/s12927-016-0011-x

Jharkharia, S., & Shukla, M. (2013). Agri-fresh produce supply chain management: A state-of-the-art literature review. *International Journal of Operations & Production Management*, *33*, 114-158. https://doi.org/10.1108/01443571311295608

Juliano, S. A. (1989). Queueing models of predation and the importance of contingent behavioural choices for optimal foragers. *Animal Behaviour*, *38*(5), 757-770. https://doi.org/https://doi.org/10.1016/S0003-3472(89)80108-3

Kaid, H., Dabwan, A., & Al-Ahmari, A. (2018). Modeling and Simulation of Queuing Systems Using Stochastic Petri net and Arena Software: A Case Study.

Kashav, S., Cerchione, R., Singh, R., Centobelli, P., & Shabani, A. (2018). Food Cold Chain Management: From A Structured Literature Review to A Conceptual Framework and Research Agenda. *The International Journal of Logistics Management*, *29*, 792-821. https://doi.org/10.1108/IJLM-01-2017-0007

Kathirvel, J., Reiyas, M., S, P., & Lakshmanan, K. (2017). An M / E K / 1 / N Queueing-Inventory System with Two Service Rates Based on Queue Lengths. *International Journal of Applied and Computational Mathematics*, *3*. https://doi.org/10.1007/s40819-017-0360-2

Ke, S.-k., Ding, M., Li, L., Niu, Q.-l., & Huang, D. (2012). Grafting watermelon seedling production management system based on process control strategy. *Journal of Shanghai Jiaotong University (Science)*, *17*. https://doi.org/10.1007/s12204-012-1241-9

Kleijnen, J., Halachmi, I., Dzidic, A., Metz, J. H. M., Speelman, L., & Dijkhuizen, A. A. (2001). Validation of simulation model for robotic milking barn design. *European Journal of Operational Research*, *134*, 677-688. https://doi.org/10.1016/S0377-2217(00)00283-6

Koh, H., Teh, S., Wong, C., Lim, H., & Migin, M. (2014). *Improving Queuing Service at McDonald's* (Vol. 1605). https://doi.org/10.1063/1.4887740

Koroliuk, V., Melikov, A., Ponomarenko, L., & Rustamov, A. (2017). Asymptotic Analysis of the System with Server Vacation and Perishable Inventory. *Cybernetics and Systems Analysis*, *53*. https://doi.org/10.1007/s10559-017-9956-0

Koroliuk, V., Melikov, A., Ponomarenko, L., & Rustamov, A. (2018). Models of Perishable Queueing-Inventory Systems with Server Vacations. *Cybernetics and Systems Analysis*, *54*, 1-14. https://doi.org/10.1007/s10559-018-0005-4

Kusumastuti, R. D., Donk, D. P. v., & Teunter, R. (2016). Crop-related harvesting and processing planning: a review. *International Journal of Production Economics*, *174*, 76-92. https://doi.org/https://doi.org/10.1016/j.ijpe.2016.01.010

Kutcher, G. P., & Norton, R. D. (1982). Operations research methods in agricultural policy analysis. *European Journal of Operational Research*, *10*(4), 333-345. https://doi.org/https://doi.org/10.1016/0377-2217(82)90084-4

Lakatos, L., Szeidl, L., & Telek, M. (2013). *Introduction to Queueing Systems with Telecommunication Applications*. https://doi.org/10.1007/978-1-4614-5317-8

Lan, C., Lan, T., & Chen, M. (2005). Optimal human resource allocation with finite servers and queuing capacity. *IJCAT*, *24*, 156-160. https://doi.org/10.1504/IJCAT.2005.007480

Landauer, E. G. (1984). The effect of random number generators on an application. *Computers & Industrial Engineering*, *8*(1), 65-72. https://doi.org/https://doi.org/10.1016/0360-8352(84)90022-6

Ledauphin, S., Pommeret, D., & Qannari, E. M. (2006). A Markovian model to study products shelf-lives. *Food Quality and Preference*, *17*, 598-603. https://doi.org/10.1016/j.foodqual.2006.04.005

Lee, D., Sönmez, E., Gómez, M. I., & Fan, X. (2017). Combining two wrongs to make two rights: Mitigating food insecurity and food waste through gleaning operations. *Food Policy*, *68*, 40-52. https://doi.org/https://doi.org/10.1016/j.foodpol.2016.12.004

Lezoche, M., Hernandez, J. E., Alemany Díaz, M. d. M. E., Panetto, H., & Kacprzyk, J. (2020). Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture. *Computers in Industry*, *117*, 103187. https://doi.org/https://doi.org/10.1016/j.compind.2020.103187

Li, B., & Wang, D. (2010). *Configuration Issues of Cashier Staff in Supermarket Based on Queuing Theory* (Vol. 106). https://doi.org/10.1007/978-3-642-16339-5_44

Liao, P.-Y. (2007a). *Optimal pricing strategy for queuing systems with capacity constraint problem* Third International Conference on Intelligent Information Hiding and Multimedia Signal Processing, (IIH-MSP 2007), Kaohsiung, Taiwan.

Liao, P.-Y. (2007b). Optimal staffing policy for queuing systems with cyclic demands waiting cost approach. Proceeding of POMS 18th Annual Conference, Dallas, Texas.

Lim, E., Kum, D., & Lee, Y. (2014). Understanding how changes within service experiences impact prospective vs. retrospective time judgments. *Journal of the Academy of Marketing Science*, *43*, 1-16. https://doi.org/10.1007/s11747-014-0415-4

Ljungberg, D., & Aradom Messmer, S. (2007). Logistics Chain of Animal Transport and Abattoir Operations. *Biosystems Engineering*, *96*, 267-277. https://doi.org/10.1016/j.biosystemseng.2006.11.003

Lowe, T., & Preckel, P. (2004). Decision Technologies for Agribusiness Problems: A Brief Review of Selected Literature and a Call for Research. *Manufacturing & Service Operations Management*, *6*, 201-208. https://doi.org/10.1287/msom.1040.0051

Lucas, M. T., & Chhajed, D. (2004). Applications of location analysis in agriculture: a survey. *Journal of the Operational Research Society*, *55*(6), 561-578. https://doi.org/10.1057/palgrave.jors.2601731

Luczak, M., & McDiarmid, C. (2006). On the maximum queue length in the supermarket model. *The Annals of Probability*, *34*. https://doi.org/10.1214/009117905000000710

Mahmoodi, A., Haji, A., & Haji, R. (2015). One for one period policy for perishable inventory. *Computers & Industrial Engineering*, *79*, 10-17. https://doi.org/https://doi.org/10.1016/j.cie.2014.10.012

Melikov, A., Ponomarenko, L., & Shahmaliyev, M. (2016). Models of Perishable Queueing-Inventory System with Repeated Customers. *Journal of Automation and Information Sciences*, *48*, 22-38. https://doi.org/10.1615/JAutomatInfScien.v48.i6.30

Mesterton-Gibbons, M. (1988). How fast can fast food be served? *Mathematical and Computer Modelling*, *10*(6), 405-407. https://doi.org/https://doi.org/10.1016/0895-7177(88)90029-5

Mittal, A., & X Krejci, R. (2017). A hybrid simulation modeling framework for regional food hubs. *Journal of Simulation*, *13*(1), 28-43.

Molnar, V., & Tumik, A. (2018). Making Unit Cost in Production Process More Accurate – the Role of Queueing. *International Journal of Engineering and Technology (UAE)*, *7*, 129-132. https://doi.org/10.14419/ijet.v7i2.23.11899

Mor, R., Bhardwaj, A., & Singh, S. (2018). A structured-literature-review of the supply chain practices in Dairy industry. *Journal of Operations and Supply Chain Management*, *11*. https://doi.org/10.12660/joscmv11n1p14-25

Morejón, Y., & Coronel, C. (2014). Use of Queueing Theory to Organization of the Complex Rice Harvest-Transport on the Agroindustrial Rice Complex "Los Palacios". *Ama, Agricultural Mechanization in Asia, Africa & Latin America*, *45*, 56-58.

MOSIMTEC. (2020). *The Key Differences Between Simulation and Optimization.* https://mosimtec.com/simulation-vs-optimization

Mouhaffel, A., Dominguez, C., Seck, A., Ahmadou, W., & Díaz Martín, R. (2016). Assessment of Mathematical Modeling to Improve Agricole Irrigation Area Works in Senegal (Kas Kas). *11*, 11950-11957.

Mullowney, P., & James, A. (2007). The role of variance in capped-rate stochastic growth models with external mortality. *Journal of Theoretical Biology*, *244*(2), 228-238.

Muslu, I., Jakshylykov, L., Soorbekova, B., Kutmanova, U., & Musiralieva, M. (2014). *Restaurant process simulation in Kyrgyzstan* 11th International Conference on Electronics, Computer and Computation (ICECCO), Abuja, Nigeria.

Nahmias, S., Perry, D., & Stadje, W. (2004). Perishable inventory systems with variable input and demand rates. *Mathematical Methods of Operational Research*, *60*, 155-162. https://doi.org/10.1007/s001860300335

Nehzati, T., Dreyer, H., & Strandhagen, J. O. (2015). Production network flexibility: Case study of Norwegian diary production network. *Advances in Manufacturing*, *3*. https://doi.org/10.1007/s40436-015-0111-8

Nematollahi, M., & Tajbakhsh, A. (2020). Past, present, and prospective themes of sustainable agricultural supply chains: A content analysis. *Journal of Cleaner Production*, *271*, 122201. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.122201

Nichols, J., Kang, S., Post, W., Wang, D., Bandaru, V., Manowitz, D., Zhang, X., & Izaurralde, R. (2011). HPC-EPIC for high resolution simulations of environmental and sustainability assessment. *Computers and Electronics in Agriculture*, *79*(2), 112-115. https://doi.org/https://doi.org/10.1016/j.compag.2011.08.012

Nooteboom, B. (1983). Productivity growth in the grocery trade. *Applied Economics*, *15*(5), 649-664

O'Laughlin, B. (1996). From Basic Needs to Safety-Nets: The Rise and Fall of Urban Food-Rationing in Mozambique. *The European Journal of Development Research*, *8*(1), 200-223. https://doi.org/10.1080/09578819608426658

Orjuela Castro, J., Sanabria, A., & Lozano, A. (2017). Coupling facility location models in the supply chain of perishable fruits. *Research in Transportation Business & Management*, *24*. https://doi.org/10.1016/j.rtbm.2017.08.002

Osborne, J., & Duffin, M. (2007). Checkout. Kroger's store front simulator. Proceedings of the 2007 Winter Simulation Conference, Washington D.C.

Palkova, Z., Rodny, T., Okenka, I., & Kiedrowicz, M. (2012). Principles of Process Controlling of Irrigation Systems Using Queuing Theory. *Rocznik Ochrona Srodowiska*, *14*, 161-171.

Parajuli, R., Thoma, G., & Matlock, M. (2019). Environmental sustainability of fruit and vegetable production supply chains in the face of climate change: A review. *Science of The Total Environment*, *650*, 2863-2879. https://doi.org/10.1016/j.scitotenv.2018.10.019

Parkan, C. (1987). Simulation of a Fast-Food Operation Where Dissatisfied Customers Renege. *Journal of the Operational Research Society*, *38*(2), 137-148. https://doi.org/10.1057/jors.1987.26

Parkan, C. (1988). How long will fast food customers wait? *Operations-Research-Spektrum*, *10*(1), 37-44. https://doi.org/10.1007/BF01720034

Patel, J. J., Patel, R. M. C. P. A., & Makwana, P. (2012). *Minimize the waiting time of customer and gain more profit in restaurant using queuing model* International Conference on Management, Humanity and Economics (ICMHE'2012), Phuket, Thailand.

Patterson, D. M. (1995). Price reform and welfare: a transition model with queuing. *Social Choice and Welfare*, *12*(3), 225-232. https://doi.org/10.1007/BF00179977

Plà, L., Sandars, D., & Higgins, A. (2013). A perspective on operational research prospects for agriculture. *Journal of the Operational Research Society*, *65*. https://doi.org/10.1057/jors.2013.45

Porter, A. L., Roper, A. T., Mason, T. W., Rossini, F. A., & Banks, J. (1991). *Forecasting and Management of Technology*. Wiley. https://books.google.com/books?id=L4Bqo1HHq7UC

Porter, S., Reay, D., Higgins, P., & Bomberg, E. (2016). A half-century of production-phase greenhouse gas emissions from food loss & waste in the global food supply chain. *Science of The Total Environment*, *571*. https://doi.org/10.1016/j.scitotenv.2016.07.041

Prakash, G. (2018). Review of the food processing supply chain literature: a UK, India bilateral context. *Journal of Advances in Management Research*, *15*. https://doi.org/10.1108/JAMR-12-2017-0116

Prasad, V., V.H, B., & Koka, T. (2015). Mathematical analysis of single queue multi server and multi queue multi server queuing models: comparison study. *Global Journal of Mathematical Analysis*, *3*, 97. https://doi.org/10.14419/gjma.v3i3.4689

Pruyn, A. T. H., & Smidts, A. (1993). Customers' evaluations of queues: three exploratory studies. *European Advances in Consumer Research*, *1*, 371-382.

Rabbani, M., & Dolatkhah, M. (2017). Simultaneous production planning of make-to-order (MTO) and make-to-stock (MTS) products using simulation optimization. Case study: Soren Restaurant. *International Journal of Advanced Logistics*, *6*, 1-15. https://doi.org/10.1080/2287108X.2017.1361290

Rajurkar, S., & Jain, R. (2011). Food supply chain management: Review, classification and analysis of literature. *International Journal of Integrated Supply Management*, *6*. https://doi.org/10.1504/IJISM.2011.038332

Ramadoss, S., & Elango, C. (2012). Markov decision processes in service facilities holding perishable inventory. *OPSEARCH*, *49*. https://doi.org/10.1007/s12597-012-0084-3

Raman, A., & Roy, D. (2015). An Analytical Modeling Framework for Determining the Optimal Table Mix in RestaurantsÕ. *IFAC-PapersOnLine*, *48*(3), 225-230. https://doi.org/https://doi.org/10.1016/j.ifacol.2015.06.085

Raz, O., & Ert, E. (2008). Size counts the effect of queue length on choice between similar restaurants. *Advances in Consumer Research*, *35*, 803-804.

Razzaghi, A. (2003). *Theories on social communication.* (1th ed.). Iran: Tehran. (In Persian).

Ridgley, M. A. (1989). Applying geographical queueing theory: a crop distribution case. *Geoforum*, *20*(4), 397-407. https://doi.org/https://doi.org/10.1016/0016-7185(89)90023-7

Rodrigues, L. F., Morabito, R., Chiyoshi, F. Y., Iannoni, A. P., & Saydam, C. (2018). Analyzing an emergency maintenance system in the agriculture stage of a Brazilian sugarcane mill using an approximate hypercube method. *Computers and Electronics in Agriculture*, *151*, 441-452. https://doi.org/https://doi.org/10.1016/j.compag.2018.06.023

Roy, D., Bandyopadhyay, A., & Banerjee, P. (2016). A nested semi-open queuing network model for analyzing dine-in restaurant performance. *Computers & Operations Research*, *65*, 29-41. https://doi.org/https://doi.org/10.1016/j.cor.2015.06.006

Saeedi, F., Teimoury, E., & Makui, A. (2019). Redesigning fruit and vegetable distribution network in Tehran using a city logistics model. *Decision Science Letters*, *8*, 45-64.

Sanctis, G., Köhler, J., & Fontana, M. (2014). Probabilistic assessment of the occupant load density in retail buildings. *Fire Safety Journal*, *69*, 1–11. https://doi.org/10.1016/j.firesaf.2014.07.002

Sayeed, S., Chowdhury, S. H., Yang, O., & Deng, Y. (2006). *The peking express problem and its application* 23rd Biennial Symposium on Communications,

Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., & Matthews, E. (2018). *Creating a sustainable food future. A menu of solutions to feed nearly 10 billion people by 2050.* https://www.wri.org/publication/creating-sustainable-food-future

Seeley, T. D. (1989). Social foraging in honey bees: how nectar foragers assess their colony's nutritional status. *Behavioral Ecology and Sociobiology*, *24*(3), 181-199. https://doi.org/10.1007/BF00292101

Sharan, G., & Madhavan, T. (1999). An Operational Study of CJ Patel Vegetable and Fruit Market of Ahmedabad. *OPSEARCH*, *36*(2), 151-164. https://doi.org/10.1007/BF03398570

Shortle, J. F., Thompson, J. M., Gross, D., & Harris, C. M. (2018). *Fundamentals of Queueing Theory* (5 ed.). Wiley. https://doi.org/10.1002/9781119453765

Siddh, M. M., Soni, G., Jain, R., Sharma, M. K., & Yadav, V. (2017). Agri-fresh food supply chain quality (AFSCQ): a literature review. *Industrial Management and Data Systems*, *117*(9), 2015–2044.

Soto-Silva, W. E., Nadal-Roig, E., González-Araya, M. C., & Pla-Aragones, L. M. (2016). Operational research models applied to the fresh fruit supply chain. *European Journal of Operational Research*, *251*(2), 345-355. https://doi.org/https://doi.org/10.1016/j.ejor.2015.08.046

Soysal, M., Bloemhof-Ruwaard, J., Meuwissen, M., & Van der Vorst, J. (2012). A Review on Quantitative Models for Sustainable Food Logistics Management. *International Journal of Food System Dynamics*, *3*, 136-155. https://doi.org/10.18461/ijfsd.v3i2.324

Stone, J., & Rahimifard, S. (2018). Resilience in agri-food supply chains: a critical analysis of the literature and synthesis of a novel framework. *Supply Chain Management: An International Journal*, *23*. https://doi.org/10.1108/SCM-06-2017-0201

Sundrum, A. (2001). Organic livestock farming: A critical review. *Livestock Production Science*, *67*(3), 207-215. https://doi.org/https://doi.org/10.1016/S0301-6226(00)00188-3

Syahruddin, N., & Kalchschmidt, M. (2011). Sustainable Supply Chain Management in the Agricultural Sector: A Literature Review. *International Journal of Engineering Management and Economics*, *3*. https://doi.org/10.1504/IJEME.2012.049894

Tanizaki, T., & Shimmura, T. (2017). Modeling and Analysis Method of Restaurant Service Process. *Procedia CIRP*, *62*, 84-89. https://doi.org/https://doi.org/10.1016/j.procir.2016.06.076

Thompson, G. M. (1998). Labor scheduling, Part2. *The Cornell Hotel and Restaurant Administration Quarterly*, *39*(6), 26-37. https://doi.org/https://doi.org/10.1016/S0010-8804(99)80003-2

Tsolakis, N. K., Keramydas, C. A., Toka, A. K., Aidonis, D. A., & Iakovou, E. T. (2014). Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy. *Biosystems Engineering*, *120*, 47-64. https://doi.org/https://doi.org/10.1016/j.biosystemseng.2013.10.014

Valenzuela, O., & Villalobos, J. (2009). Application of Planning Models in the Agri-Food Supply Chain: A Review. *European Journal of Operational Research*, *196*, 1-20. https://doi.org/10.1016/j.ejor.2008.02.014

van 't Ooster, A., Bontsema, J., van Henten, E. J., & Hemming, S. (2012). GWorkS – A discrete event simulation model on crop handling processes in a mobile rose cultivation system. *Biosystems Engineering*, *112*(2), 108-120. https://doi.org/https://doi.org/10.1016/j.biosystemseng.2012.03.004

Venkatadri, U., Vardarajan, V., & Das, B. (2014). Product placement within a fast-picking tunnel of a distribution centre. *The International Journal of Advanced Manufacturing Technology*, *76*(9), 1681-1690. https://doi.org/10.1007/s00170-014-6389-z

Vrat, P., Gupta, R., Bhatnagar, A., Pathak, D., & Fulzele, V. (2018). Literature review analytics (LRA) on sustainable cold-chain for perishable food products: research trends and future directions. *OPSEARCH*, *55*, 601-627. https://doi.org/10.1007/s12597-018-0338-9

W. Whitney, R., & J. Cochran, B. (1976). Predicting Sugar Cane Mill Delivery Rates. *Transactions of the ASAE*, *19*(1), 47-0048. https://doi.org/https://doi.org/10.13031/2013.35964

Wagner, M. R., Bhadury, J., & Peng, S. (2009). Risk management in uncapacitated facility location models with random demands. *Computers & Operations Research*, *36*(4), 1002-1011. https://doi.org/https://doi.org/10.1016/j.cor.2007.12.008

Weintraub, A., & Romero, C. (2006). Operations Research Models and the Management of Agricultural and Forestry Resources: A Review and Comparison. *Interfaces*, *36*. https://doi.org/10.1287/inte.1060.0222

Weiss, E., & Tucker, C. (2018). Queue management: Elimination, expectation, and enhancement. *Business Horizons*, *61*. https://doi.org/10.1016/j.bushor.2018.05.002

Weng, s.-j., Gotcher, D., & Kuo, C. (2016). Lining up for quick service—The business impact of express lines on fast-food restaurant operations. *Journal of Foodservice Business Research*, *20*, 1-17. https://doi.org/10.1080/15378020.2016.1195217

Wirtz, K. (2012). Intermittency in processing explains the diversity and shape of functional grazing responses. *Oecologia*, *169*, 879-894. https://doi.org/10.1007/s00442-012-2257-4

Wyman, F. P., & Orr, W. M. (1973). Queueing with Cyclic Arrival Distributions and Variable Service Facilities: A Simulation Approach. *Journal of the Operational Research Society*, *24*(4), 593-601. https://doi.org/10.1057/jors.1973.108

Yang, W. (2018). A user-choice model for locating congested fast charging stations. *Transportation Research Part E: Logistics and Transportation Review*, *110*, 189-213. https://doi.org/10.1016/j.tre.2017.11.009

Yavari, M., & Geraeli, M. (2019). Heuristic Method for Robust Optimization Model for Green Closed-Loop Supply Chain Network Design of Perishable Goods. *Journal of Cleaner Production*, *226*. https://doi.org/10.1016/j.jclepro.2019.03.279

Zhang, T., Zhao, F., Zhang, J., Mendis, G., Ru, Y., & Sutherladn, J. W. (2019). An Approximation of the Customer Waiting Time for Online Restaurants Owning Delivery System. *Journal of Systems Science and Complexity*, *32*(3), 907-931. https://doi.org/10.1007/s11424-018-7316-4

Zhang, W., & Wilhelm, W. (2011). OR/MS decision support models for the specialty crops industry: A literature review. *Annals OR, 190*, 131-148. https://doi.org/10.1007/s10479-009-0626-0

Zhong, R., Xu, X., & Wang, L. (2017). Food supply chain management: systems, implementations, and future research. *Industrial Management & Data Systems*, *117*, 2085-2114. https://doi.org/10.1108/IMDS-09-2016-0391

Zhu, Z., Chu, F., Dolgui, A., Chu, C., Zhou, W., & Piramuthu, S. (2018). Recent Advances and Opportunities in Sustainable Food Supply Chain: A Model-oriented Review. *International Journal of Production Research*. https://doi.org/10.1080/00207543.2018.1425014

APPENDIX

TABLE A.I: Food System Design

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Graves, 1982	perishable products	D_5	proposing two models for studying the steady-state distribution of products by queuing theory (with Poisson demand requests and single server and finite queue)
Pruyn & Smidts, 1993	restaurant	D_4	applying a methodology for experimenting with customers' reactions to two different queuing layouts
O'Laughlin, 1996	urban food	D_5	using the queuing system to distribute the food
Field et al., 1997	restaurant	D_4	presenting Monte Carlo simulation for studying the relation of buffet layout and redesigning the floor plan with the queue's waiting times
Ridgley, 1989	agricultural of vegetables and bananas	D_5	Monte Carlo simulation to analyze products distribution system (geographical queueing)
Kleijnen et al., 2001	milking barn	D_2-D_3-D_4	using a behavior-based simulation model for designing milking barn and optimizing the layout and facility allocation (by queuing concept)
Halachmi, 2004 / Halachmi et al., 2003	milking farm	D_1-D_3-D_4	applying a mathematical simulation model for designing a milking farm (by queuing concept)
Sayeed et al., 2006	Chinese-food restaurant	D_5	offering a simulation model to evaluate the performance of a queuing system
Halachmi, 2007	edible fish	D_4	applying the queuing theory for optimizing the system layout
Osborne & Duffin, 2007	grocery retailer	D_4	proposing a simulation model according to queuing theory for providing a drag-and-drop layout capability
Argent-Katwala & Bradley, 2007	dairy shop	D_3	introducing PEPA queues for routing in queueing networks
Ljungberg et al., 2007	abattoir	D_3	Optimizing and analyzing the logistics chain of animal transport and abattoir operations
Wagner et al., 2009	grocery store	D_1-D_2	considering a location-optimization problem (by queuing concept at solution approach)
Hwang et al., 2010	restaurant	D_5	developing a queueing-based optimization model with underlying quasi birth-and-death process and state-dependent functions
Palkova et al., 2012	agriculture	D_5	presenting a method based on queuing theory for controlling of irrigation of agricultural land
Halachmi, 2012	edible fish	D_4	describing the management of an effective layout by a queuing system
Adamczuk & Lindau, 2012	broiler chickens	D_2-D_5	presenting a framework for collecting and delivery using a queuing model

Continue TABLE A.I: Food System Design

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Halachmi, 2013	edible fish	D_4	developing an integrated model (queuing, optimization, and simulation linked together)
Venkatadri et al., 2014	beverage industry (alcohol)	D_1-D_4-D_5	presenting an optimization model and offering a simulation model to evaluate the queuing of a given product placement strategy
Roy et al., 2016	dine-in restaurant	D_2	developing a stochastic model and a nested queueing network
Nehzati et al., 2015	dairy production	D_5	identifying different dimensions of flexibility in a distribution network and applying network queuing theory indicator
Raman & Roy, 2015	walk-in restaurant	D_2	presenting a queuing theory-based optimization model by an allotment policy
Ghaleb et al., 2015	student restaurant	D_4	using Arena simulation to develop several alternatives
Iman & Borimnejad, 2016	chain grocery store	D_1	evaluating the system performance quality by queuing approach
Weng et al., 2016	Fast-food restaurant	D_4-D_5	proposing a simulation model for examining queuing times in three different line scenarios/ using variance analysis and posthoc tests
Tanizaki & Shimmura, 2017	restaurant	D_4	analyzing the relationship among the seat layout and customers queuing with computer simulation
Rabbani & Dolatkhah, 2017	restaurant	D_2-D_4	using a discrete event method
Mittal & X Krejci, 2017	food hub	D_5	using ABM and DES simulations
Inman & Nikolova, 2017	grocery store	D_1	presenting a shopper-centric decision calculus that retailers can use when considering a new shopper-facing technology
De Vries et al., 2018	restaurant	D_2-D_4	proposing a simulation model based on queuing model
Yang, 2018	grocery store	D_1	using a maximal coverage problem and deploying facility in a stochastic environment (system M/M/k)
Boywitz & Boysen, 2018	food industry	D_2	introducing a new way to conclude robust storage allocations
Comi et al., 2018	foodstuffs	D_1-D_5	prepossessing a methodology to design system/ using simulation-based approach/ introducing the architecture of an app-oriented tool
Gao et al., 2018	restaurant	D_5	combining the basic model of queuing theory and retailer's profit function
Saeedi et al., 2019	Fruit and vegetable	D_1-D_5	proposing a bi-objective mathematical model

TABLE A.II: Food System Support

Reference	***Subject***	***Subgroup***	***Approach/ Procedure***
Wyman & Orr, 1973	Quick-service restaurant	S_1-S_4	using a simulation for evaluating the range of resources
W. Whitney & Cochran, 1976	sugarcane	S_2	developing a model based on queuing theory for predicting the resources
Nooteboom, 1983	grocery trade	S_1	presenting a model using the economies of scale and a function based on the wage rate, part-time labor, labor supply, and demand
Parkan, 1987 and 1988	Fast-food kiosk	S_1	modeling the number of personnel decision making
Farahmand & Martinez, 1996	Fast-food restaurant	S_1	proposing a model for simulating and animating the system (for forecasting)
Field et al., 1997	restaurant	S_1-S_4	using Monte Carlo simulation for investigating the number of resources
Thompson, 1998	restaurant	S_1	studying a queuing model for determining resources and economic standards
Blanckenhorn et al., 1998	food	S_3	proposing a queuing model for monopolization in a resource queue
Sharan & Madhavan, 1999	Fruit and vegetable	S_2	surveying a dynamic queuing system and constructing a simulation model for it
Halachmi, 2004 / Halachmi et al., 2003	milking farm	S_4	applying a mathematical simulation
Lan et al., 2005	Fast-food store	S_1	proposing an optimization model considering a multi-station queuing theory
Liao, 2007a	restaurant	S_1	presenting an optimization approach
Sayeed et al., 2006	Chinese-food restaurant	S_1	offering a simulation to evaluate the performance of a queuing system
Osborne & Duffin, 2007	grocery retailer	S_1	proposing a simulation model according to queuing theory
Liao, 2007b	Fast-food restaurant	S_1	presenting an optimization approach
Chou & Liu, 2008	Fast-food restaurant	S_1	building a simulation model to study the queuing system
Li & Wang, 2010	supermarket	S_1	building the mathematical model about service system based on queuing theory
Nichols et al., 2011	food	S_1	employing the job queuing system and Portable Batch System (PBS)
van 't Ooster et al., 2012	horticultural crop	S_1-S_4	presenting of queueing network model (GWorkS-rose)

Continue TABLE A.II: Food System Support

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Adamczuk & Lindau, 2012	broiler chickens	S_1	presenting a framework for collecting and delivery using a queuing model
Ke et al., 2012	watermelon	S_3	production management based on process control methods using the queuing theory
Halachmi, 2013	edible fish	S_4	developing an integrated model (queuing, optimization, and simulation linked together)
Ampatzidis et al., 2014	fruit	S_4	adopting a modified machine repair model
Aggarwal et al., 2014	butter oil	S_4	proposing a Markov-queuing process for availability analysis and a system performance optimization
Morejón & Coronel, 2014	rice	S_2	applying the queuing theory and studying the economic features
Austria, 2015	Quick-service restaurants	S_4	implementing the queue management practices
Roy et al., 2016	dine-in restaurant	S_1-S_4	developing a stochastic model/ introducing a nested queueing network
Ding et al., 2014	grocery store	S_1	introducing an approximation procedure and interpreting the system
Mouhaffel et al., 2016	rice	S_2	optimizing the number of resources according to the queuing theory models
Hanukov et al., 2017	Fast-food industry	S_3	studying a single-server queue
Mittal & X Krejci, 2017	food hub	S_1	using the simulation of ABM and DES
Koroliuk et al., 2017	perishable products	S_1	proposing a Markovian model considering the queuing-inventory system
de Oliveira & Keeling, 2018	dairy cow	S_3	presenting a new methodology for identifying and validating the behavioral indicators
Rodrigues et al., 2018	sugarcane	S_4	applying an approximate hypercube queuing method
Weiss & Tucker, 2018	restaurant	S_4	introducing electronic resource to eliminate waiting time
Hanukov et al., 2019	Fast-food industry	S_3	combining the queueing and the inventory models
Saeedi et al., 2019	Fruit and vegetable	S_2	proposing a bi-objective mathematical model based on queuing theory
Zhang et al., 2019	Online restaurant	S_2	approximating the meal preparation and delivery processes by applying queueing theory

TABLE A.III: Food System Operation

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Wyman & Orr, 1973	quick service restaurant	O_5	developing a policy to optimum opening a second counter processes
Bart, 1982	grocery store	O_2	presenting a new theory for calculating the system's cost
Nooteboom, 1983	grocery trade	O_2	presenting a model using the economies of scale and a function based on the wage rate, part-time labor, labor supply, and demand
Landauer, 1984	grocery store	O_5	comparing the results of a simulation study involving four basic generators basic generators
Parkan, 1987	Fast-food kiosk	O_3-O_7	presenting a queuing model for examining some system's parameters
Mesterton-Gibbons, 1988	Fast-food restaurant	O_1	introducing the queuing system for guarantying serving food within u minutes
Parkan, 1988	Fast-food kiosk	O_3-O_5-O_6	providing a model based on queuing theory and a simulation for comparing two real-world case
Seeley, 1989	honey bee	O_1-O_4	introducing the mathematical theory for investigating the behavior of queues
Juliano, 1989	food (foraging)	O_3-O_4-O_7	presenting a queueing model to develop a behavior of servers and customers
Pruyn & Smidts, 1993	restaurant	O_7	presenting a methodology/ testing four specific hypotheses
Goh et al., 1993	perishable products	O_5- O_6	considering an inventory-queuing system/ analyzing system's parameters
Patterson, 1995	food	O_2	developing an equilibrium exchange economy model with relative price distortions
Farahmand & Martinez, 1996	Fast-food restaurant	O_1-O_4	proposing a model for simulating and animating the system (for forecasting)
Blanckenhorn et al., 1998	food	O_5	proposing a queuing model for monopolization in a resource queue
Beyer, 1998	food (feeding behavior)	O_1-O_4-O_5	simulation of digestive activity in the stomach using queuing theory
Sharan & Madhavan, 1999	Fruit and vegetable	O_5	surveying a dynamic queuing system and constructing a simulation model for it
Halachmi et al., 2000	dairy barn	O_1-O_4	developing of a closed queuing network model
Evers, 2004	slaughter	O_4-O_7	introducing a mathematical model using the queuing concept

Continue TABLE A.III: Food System Operation

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Nahmias et al., 2004	perishable products	O_3-O_5	Considering a queuing-inventory system using Markovian process, in the condition of a certain class and random arriving times
Lan et al., 2005	Fast-food store	O_3-O_4-O_6	proposing multi-station queuing theory along with the cumulative probability function
Ledauphin et al., 2006	shelf-lives products	O_7	considering an experiment for investigating the dynamic of degradation of products quality by a Markovian model
Batabyal & Yoo, 2006	rice	O_5	analyzing the system using a queuing model in a stability condition
Luczak & McDiarmid, 2006	supermarket	O_4	providing mathematical proofs for calculating the queue length
Liao, 2007a	restaurant	O_6	presenting a queuing model to formulate waiting cost as a balking loss
Ljungberg et al., 2007	abattoir	O_7	Optimizing and analyzing the logistics chain of animal transport and abattoir operations
Halachmi, 2007	edible fish	O_5	applying queuing theory for optimizing some system's parameters
Osborne & Duffin, 2007	grocery retailer	O_3	proposing a simulation model according to queuing theory
Liao, 2007b	Fast-food restaurant	O_3	presenting a queuing approach to formulate waiting cost
Mullowney & James, 2007	food	O_5	applying a queuing theory model for modeling the growth of individuals in a stochastic environment/ analyzing the system using various distributions
Argent-Katwala & Bradley, 2007	dairy shop	O_3	introducing PEPA queues (customer cooperation)
Raz & Ert, 2008	restaurant	O_3-O_4-O_7	studying the relationship between queue length with the quality and customers choice
Analoui & Jamali, 2008	food	O_4	proposing the congestion control model using active queue management
Chen, 2008	McDonald's	O_5	prepossessing a fuzzy mathematical programming approach based on classical queuing model
Dharmawirya & Adi, 2011	restaurant	O_1-O_4-O_5	studying the application of queueing theory in the system and calculating the queuing's factor
Palkova et al., 2012	agriculture	O_6	presenting a method based on queuing theory for controlling some system's parameters
Ke et al., 2012	watermelon	O_4-O_7	production management based on process control methods using the queuing theory

Continue TABLE A.III: Food System Operation

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Wirtz, 2012	food	O_4	applying elements of the queuing theory for the digestive system in the gut
Halachmi, 2012	edible fish	O_5	introducing a recirculating aquaculture system design by queuing system
Ramadoss & Elango, 2012	restaurant (meat)	O_2	modeling the problem as a Markov decision problem using the value iteration algorithm
Patel et al., 2012	restaurant	O_3- O_5	satisfying a numerical model when tested with a real-case scenario by queuing theory
Halachmi, 2013	edible fish	O_1-O_5	developing an integrated optimization model (queuing, optimization, and simulation linked together)
Abulah, 2013	Fast-food restaurant	O_1	modeling and evaluation of two queuing systems and comparing them
Battini et al., 2014	dairy goats	O_7	using the queuing factor for assessment of good feeding of dairy goats
Morejón & Coronel, 2014	rice	O_7	applying the queuing theory and studying the economic features
Lim et al., 2014	restaurant	O_1	managing the waiting time of the system using queuing concepts
Sanctis et al., 2014	Supermarkets (selling predominantly food articles)	O_1-O_5	applying a probabilistic approach to describing the variability of the occupant load density during a year, using methods from the queuing theory
Mahmoodi et al., 2015	perishable products	O_1	combining the inventory, the queueing, and the finite dam models/ proposing a numerical analysis
Prasad et al., 2015	supermarket	O2	proposing mathematical analysis for comparison of two queuing models
Muslu et al., 2014	Fast-food restaurant	O_2	proposing a simulation approach based on a queuing model
Koh et al., 2014	McDonald’s	O_1	implementing a queuing system in the system and monitoring its factors/ utilizing Que-app to performing queuing analysis at this system
Venkatadri et al., 2014	beverage industry (alcohol)	O_5-O_7	presenting an optimization model and offering a simulation model to evaluate the queuing of a given product placement strategy
Austria, 2015	Quick-service restaurants	O_1-O_5	implementing the queue management practices for assessing the level of satisfaction of the customers
Ding et al., 2014	grocery store	O_3	introducing an approximation procedure and interpreting the system
Ghaleb et al., 2015	student restaurant	O_7	using Arena simulation to get better service quality

Continue TABLE A.III: Food System Operation

Reference	*Subject*	*Subgroup*	*Approach/ Procedure*
Weng et al., 2016	Fast-food restaurant	O_5	proposing a simulation model for examining queuing times in three different line scenarios/ using variance analysis and posthoc tests
Mouhaffel et al., 2016	rice	O_5	optimizing the number of resources according to the queuing theory models/ evaluating the total amount lost due to idleness
Jain & Ali, 2016	take away restaurant	O_1	proposing a simulation model to evaluate the system's performance
Gumus et al., 2017	Fast-food restaurant	O_1-O_3-O_5	using the M/M/s queuing model for evaluating system's factors
Dubosson et al., 2018	food	O_3	choosing large-scale food distribution sector for application of a naturalistic observation to describe in detail the behavior of customer queue
Inman & Nikolova, 2017	grocery store	O_1	presenting a shopper-centric decision calculus that retailers can use when considering a new shopper-facing technology
Mittal & X Krejci, 2017	food hub	O_6	using the simulation of ABM and DES
Koroliuk et al., 2017	perishable products	O_4-O_6	proposing a Markovian model considering a queuing-inventory system
Tanizaki & Shimmura, 2017	restaurant	O_3	proposing a simulation method based on queuing theory for analyzing the system's parameters
Kathirvel et al., 2017	perishable products	O_3	a finite queueing system ($M/E_k/1/N$) with a continuous review (s, Q) ordering policy for investigating a system (The Laplace–Stieltjes transforms of waiting time distribution were derived. Also balking with the fixed probability was considered.)
Lee et al., 2017	food	O_1	developing a stochastic optimization model in the condition of uncertainty donations arrival
De Vries et al., 2018	restaurant	O_1-O_2-O_3	proposing a simulation model based on queuing theory
Yang, 2018	grocery store	O_3	using a maximal coverage problem and deploying facility in a stochastic environment (system M/M/k)
Rodrigues et al., 2018	sugarcane	O_5-O_6	applying an approximate hypercube queuing method
Kaid et al., 2018	student restaurant	O_1-O_5	modeling and simulation of queuing systems using stochastic Petri net and Arena software/ applying VIKOR approach
Hanukov et al., 2019	Fast-food industry	O_1	combining the queueing and the inventory models
Gao et al., 2018	restaurant	O_7	combining the basic model of queuing theory and retailer's profit function