Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 3254532, 11 pages
https://doi.org/10.1155/2022/3254532

Research Article

A Novel Approach for Sustainable Supply Chain Management with Analyzing the Effective Governance under Fuzzy Uncertainty

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Received 12 June 2022; Revised 23 July 2022; Accepted 28 July 2022; Published 19 September 2022

Academic Editor: Reza Lotfi

Nowadays, knowledge has become one of the most important tools of power, distributing public services that accept the audience as citizens and not consumers and provide the principle of services without financial worries. Moreover, the urban products have a specific production and distribution channel that should be assessed. In this research, a mathematical framework is proposed for designing the supply chain network of urban products. The main contribution of this research is to incorporate the effect of public service into urban products' supply chain planning. In this regard, a mixed-integer mathematical model is proposed. In this mathematical model, an attempt is made to minimize the costs of the product distribution system by considering the effects of production, maintenance, and distribution. Moreover, fuzzy uncertainty has been applied to adapt the mathematical model to real conditions. The numerical results show that if manufacturers and distributors want to strengthen their institutions and maintain their leadership roles as in the past, they can optimize their distribution network structure to achieve the best possible performance. Moreover, technological advances and innovations in production and distribution systems can create a huge leap in profitability.

1. Introduction

Since the existence of human beings, there has been change and transformation all over the world, in every field. In particular, states have turned into traditional, modern, post-modern, liberal, interventionist, regulatory, and reregulating state understanding. In the transformation process of the state, the organizational structure, the service, and management it carries out have changed along with it, and the public administration, which is the state's functioning mechanism and means of providing public services, has been at the center of this differentiation. In this regard, urban and rural transportation for required products is one of the most important factors for providing suitable sustainable development [1, 2].

In addition to production and distribution, new methods have revealed ways to provide faster, more effective, and quality public services to citizens, business circles, and nongovernmental organizations [3].

The study consists of five sections. First, the transition from management understanding the rural transportation of required products as a result of changes in public administration is discussed, and the related concepts are explained. Then, a novel mathematical model is proposed to find optimal decisions. Next, the numerical results are presented, and finally, the discussion is provided.

2. Literature Review

Public administration, which has become an integral part of daily life as the state's means of action and business, has constantly been changing with the growth and development of the state and the increasing needs of the people from the early ages to the present day [4, 5].

In the nineteenth century, the state was traditionally the Gendarmerie, which had classical duties such as security, justice, and foreign policy, and it rapidly changed as a result of economic issues (1929 and 1973 crises) at the beginning of the twentieth century [6]. The change of the state has also changed the understanding of public administration [7].

As a result, researchers suggested that the state should take guiding decisions in order to ensure efficient use of resources in the economy, have a fair distribution of income, achieve economic growth and development, and ensure economic stability, that is, the state should be steering rather than rowing [8]. With Keynes's policies, it was accepted that the state should take a more active role in the economic and social field [8, 9].

There was a need for an understanding to make public administration both efficient and responsible for its decisions and transactions [10]. The spread of democratization discourses after 1980, localization, globalization, technological development, and the importance of nongovernmental organizations transformed the understanding of public administration into a new understanding of public administration [11]. The new public management approach is a flexible, transparent structure that defends the application of market techniques to the public, gives the manager wide authority, brings competition to the public sector, citizen-centered, soft hierarchy, and decentralization [12]. The new public administration aims to eliminate bureaucracy and paperwork in public, accelerate access to services with the effective and efficient use of technology, and use public resources more efficiently with target-oriented, performance-based service delivery [13].

These are considered key factors in determining the level of good governance [14]. There is also a relationship between democracy and good governance, as good governance is located in a functioning democratic system with freedom of expression, equality, and a sound legal system [15]. Similarly, the United Nations Economic and Social Commission for Asia and Pacific has listed eight main features of good governance: participatory, consensus and legal rules, accountable, transparent, sensitive, effective and efficient, and equitable. Good governance aims to provide more and higher-quality services to the public at less cost [16, 17]. It does this only with an accountable, participatory, transparent, and effective management approach [18].

Therefore, there is no general definition of public service. Public service, which is one of the most fundamental issues of administrative law, is the activity carried out by public legal entities or private persons under their control in order to satisfy a common and general need that has gained importance in society [19].

Public service is the activities carried out by the state and other public institutions directly or under the strict supervision, control, and responsibility of a public institution to meet the needs of society. Public service is an activity for the purpose of the public benefit provided or undertaken by a public legal entity [20].

Public service can improve public product distributions [21]. In organic terms, the public service is defined as the whole of agents and means allocated by a public legal entity to carry out certain tasks, while the public service in material terms is completely independent of the characteristics of the organization carrying out the activity, only by looking at the nature of the activity [22, 23]. In terms of form, public service refers to a particular procedure and a certain legal regime [21].

The principle of public service has a significant effect on public product distribution. Public product distribution meets public needs rather than private needs and targets the public good. The legislature will appreciate whether a need has gained social significance to the extent that it requires the establishment of public service [22–24].

The fact that commercial channels include more colorful entertainment programs has accelerated the attractiveness of the broadcasts to the audience. Therefore, most public service broadcasters have made some important changes to the program's appearance in the face of competition [25]. The globalizing communication environment has enabled public service broadcasting to become global, thus changing the traditional program strategy.

Public broadcasters have learned to adapt to commercial media markets by making their bureaucracies ruder and lean, choosing a middle ground between popularization and purification in their program strategy [26]. Based on this dominant approach, in terms of public service broadcasting, a management style in which the public is defined as a customer, competition is praised, and marketization and the understanding of earning income from external sources are encouraged has come to the fore [27].

After reviewing the different aspects of public service and urban products supply chain, the main research gap and the contribution of this research can be presented at the integration of public service quality and urban products supply chain planning using an optimization approach.

3. Materials and Methods

3.1. Public Broadcasting with Secondary Data. With the effect of technological developments in the twenty-first century, conditions have changed, and they continue to change day by day. Businesses are working to be able to survive in the global competition and maintain their existence. One of the most important means of achieving this is the strategic public relations function of the organizations and the corporate reputation management, which is one of the most important functions of this function [28]. In recent years, social media has started to be used in all areas. Institutions are also directed to social media and work to improve their corporate reputation in these environments. At this point, whether or not the fact that social media is used effectively by institutions is of utmost importance in terms of reputation [29, 30].

3.2. Proposed Mathematical Model. In this study, in order to show innovative activities in the automotive industry, a

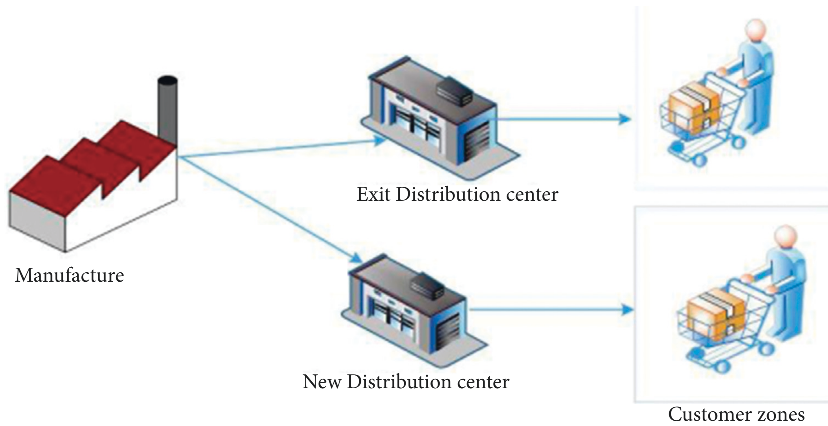

Figure 1: The studded transportation network.

mathematical model of inventory location to redesign warehouses in a multiproduct three-level supply chain for the automotive industry is presented. The structure of the proposed supply chain is inspired by [31–33]. The supply chain network in question includes the manufacturer, candidate points for the construction of new and existing warehouses, as well as customers, as shown in Figure 1.

Existing warehouses can be closed during one of the strategic planning periods, and during the planning period, new warehouses can be opened at one of the candidate points at different strength levels. If one of the active distribution centers is closed during the planning period, it cannot be activated until the end of the planned period, and if a new warehouse is built in one of the candidate points during one of the periods, it cannot be closed until the end of the period.

Active warehouses can increase their capacity over time. The costs considered in this section include the fixed cost of constructing a new warehouse, the cost of closing an existing plant, and the costs associated with increasing the capacity of active plants in each time period. Each customer is assigned to one of the active warehouses in each of the time periods, considering the capacity limit, and in each warehouse, based on the amount of demand allocated to the warehouse, they issue an order from the manufacturer [34].

A fixed amount inventory policy (Q, r) is considered taking into account the lack of recovery in each warehouse in order to determine the optimal order amount from the manufacturer. It should be noted that according to [34], the total cost of inventory in (Q, r) systems is calculated based on a nonlinear formulation.

In each of the time periods, a certain percentage of customer demand is faced with a shortage of backlog and is not met, and a percentage of the shortage is met in the next period. The costs considered in this section include inventory maintenance costs, warehouse ordering costs, the costs of transporting products from the manufacturer to the warehouses, the fixed cost of constructing the warehouses, the cost of closing the existing warehouses, the operating costs of the active warehouses in each period, as well as the costs of shortages. Due to the inherent uncertainty in the parameters of the problem, the parameters related to cost and customer demand have been considered fuzzy, and the efficient method of Jimmenez [35] has been used to deal with uncertainties [34].

3.2.1. Sets

$w \in w^e \cup w^n = \{1, 2, \ldots, w\}$: Set of warehouses

$w^e = \{1, 2, \ldots, w^e\}$: Set of available warehouses

$w^n = \{1, 2, \ldots, w^n\}$: Set of warehouses which are possible to establish

$k_w = \{1, 2, \ldots, k_w\}$: Set of warehouses capacity levels

$C = \{1, 2, \ldots, c\}$: Set of customers

$P = \{1, 2, \ldots, p\}$: Set of final products

$T = \{1, 2, \ldots, t\}$: Set of time periods

$T_L \in T = \{1, 2, \ldots, t_1\}$: Strategic time periods in which new facilities can be built, shut down existing facilities, and increase facility capacity

$U = \{1, 2, \ldots, u\}$: Set of consolidation levels

3.2.2. Parameters

fc_{tj}^u: Fixed cost of establishing a warehouse $j \in w^n$ at level of $u \in U$ in period $t \in T_1$

sc_{tj}: Fixed cost of closing warehouse $j \in w^e$ in period $t \in T_1$

ic_{tjk}: Cost of establishing capacity level $k \in k_w$ in location $j \in w$ in period $t \in T_1$

oc_{tj}: Operation cost in location $j \in w$ in period $t \in T$

sf_{tj}: Cost saving in closing warehouse $j \in w$ in period $t \in T_1$

fo_{wtp}: Fixed cost of transportation of product $p \in P$ from warehouse $w \in w^e \cup w^n$ in period $t \in T$

g_{wtp}: Fixed cost of ordering product $p \in P$ from warehouse $\in w^e \cup w^n$ in period $t \in T$

h_{wp}^t: Holding cost of product $p \in P$ in warehouse $w \in w^e \cup w^n$ in period $t \in T$

a_{twp}: Variable cost of distribution product $p \in P$ from warehouse $w \in w^e \cup w^n$ in period $t \in T$

Q_j^e: capacity of available warehouse $j \in w^e$ in period $t \in T$

l_{wt}^p: Lead time of product $p \in P$ in warehouse $w \in w^e \cup w^n$ in period $t \in T$

$\sigma_{cp}^{2,t}$: Variance of demand for customer $c \in C$ for product $p \in P$ in period $t \in T$

μ_{cpt}: Mean demand of customer $c \in C$ for product $p \in P$ in period $t \in T$

β: Weight of holding costs

θ: Weight of distribution costs

ρ_{tp}: Percentage of backorder of product $p \in P$ in period $t \in T$

π_0: Fixed cost of backorders

π_{tp}: Variable cost of backorder of product $p \in$ in period $t \in T$

ω_0: Fixed cost of lost sales

ω_{tp}: Variable cost of lost sales of product $p \in P$ in period $t \in T$

ξ_0: Average shortage cost

ξ_{tp}: Average shortage time in period $t \in T$

3.2.3. Variables

$Y_{t,j}^{nu}$: Binary variable and equal to 1 if warehouse $j \in w^n$ is established in period $t \in T_L$ in consolidation level $u \in U$

$Y_{t,j}^e$: Binary variable and equal to 1 if warehouse in location $i \in w^e$ is closed in period $t \in T_L$

Z_{wcrtp}: Binary variable and equal to 1 if customer $c \in C$ is assigned to warehouse $w \in w^e \cup w^n$ in period $t \in T$ for providing product $p \in P$

U_{tjk}: Binary variable and equal to 1 if capacity level $k \in k_w$ is assigned to warehouse $j \in w$ in period $t \in T_L$

A_{tj}^n: Amount of capacity in warehouse $j \in w^e$ in period $t \in T$

A_{tj}^e: Amount of capacity in warehouse $j \in w^n$ in period $t \in T$

3.2.4. Mathematical Formulation

$$MinZ = \sum_{t\in T_L}\sum_{j\in w^n}\sum_{u} fc_{tj}^{u} y_{tj}^{nu} + \sum_{t\in T_L}\sum_{j\in w^e} sc_{tj}Y_{tj}^{e} + \sum_{t\in T_L}\sum_{j\in w}\sum_{k\in k_j} ic_{tjk}U_{tjk} - \sum_{j\in w^e} sf_{tj}\left(\sum_{t\in T_L} Y_{tj}^{e}\right)$$
$$+\left(\sum_{w}\sum_{p}\sum_{t}\sum_{c}\left(\sqrt{2\left(\theta fo_{\text{wtp}} + \beta g_{\text{wtp}}\right)\mu_{\text{ctps}}Z_{\text{wctps}}\theta h_{\text{wtp}} - \frac{\theta h_{\text{wtp}}\left(\xi_0\mu_{\text{ctp}}Z_{\text{wctp}}\right)^2}{\theta h_{\text{wtp}}+\xi_{tp}}}\sqrt{\frac{\xi_{tp}}{\theta h_{\text{wtp}}+\xi_{tp}}}\right)\right.$$
$$\left.+\theta\sum_{w}\sum_{p}\sum_{t}\sum_{c}\left(\frac{\theta h_{\text{wtp}}\xi_0\mu_{\text{ctp}}Z_{\text{wctp}}}{h_{\text{wtp}}+\xi_{tp}}\right)\right) \tag{1}$$
$$=\left(\theta\sum_{w}\sum_{p}\sum_{t}\sum_{c} Z_{\text{wctp}}\mu_{\text{ctp}}a_{\text{wtp}} + \beta\sum_{w}\sum_{p}\sum_{t} h_{\text{wtp}}Z_a\sqrt{L_{wt}^{p}\left(\sum_{c}\delta_{cp}^{t}Z_{\text{wctp}}\right)}\sum_{w}\sum_{p}\sum_{t}\sum_{c} Z_{\text{wctp}}\mu_{\text{ctp}}a_{\text{wtp}}\right.$$
$$\left.+\sum_{r}\sum_{h}\sum_{t}\sum_{w} rh_{\text{twr}}cr_{tw}\right),$$

$$\sum_{t\in T_L}\sum_{u} Y_{tj}^{un} \le 1 \quad \forall j \in w^n, \tag{2}$$

$$\sum_{u} Y_{tj}^{un} \le \sum_{k\in k_j} U_{tkj} \le \sum_{\tau=1,\tau\in T_L}^{t}\sum_{u} Y_{\tau j}^{un} \quad \forall t \in T, j \in w^n, \tag{3}$$

$$\sum_{k\in k_j} U_{tkj} \le 1 - \sum_{\tau=1,\tau\in T_L}^{|T|} Y_{\tau j}^{e} \quad \forall t \in T_L, j \in w^e, \tag{4}$$

$$A_{tj}^{n} = A_{(t-1)j}^{n} + \sum_{k\in k_j} Q_{jk}u_{tjk} \quad \forall j \in w^n, t \in T, \tag{5}$$

$$A_{tj}^{e} = \sum_{k\in k_j} Q_{jk} u_{tjk} + A_{(t-1)j}^{e} \quad \forall j \in w^{e}, t \in T, \tag{6}$$

$$\sum_{j\in w} Z_{\text{jcpt}} = 1 \quad \forall j \in x^{n}, p \in P, c \in C, t \in T, \tag{7}$$

$$Z_{\text{jcpt}} \leq \sum_{\tau=1,\tau \in T_L}^{t} \sum_{h} Y_{\tau jh}^{n} \quad \forall j \in w^{n}, p \in P, t \in T, \tag{8}$$

$$Z_{\text{jcpt}} \leq 1 - \sum_{\tau=1,\tau \in T_L}^{|T|} \sum_{h} Y_{\tau j}^{e} \quad \forall j \in w^{e}, p \in P, t \in T, \tag{9}$$

$$\sum_{c} \sum_{p} Z_{jcpt} \mu_{ctp} \leq A_{tj}^{n} \quad \forall j \in w^{e}, p \in P, t \in T, \tag{10}$$

$$\sum_{c} \sum_{p} Z_{jcpt} \mu_{ctp} \leq A_{tj}^{e} \quad \forall j \in w^{e}, p \in P, t \in T, \tag{11}$$

$$Y_{t,j}^{n,u}, Y_{t,j}^{e}, Z_{jcpt}, U_{tjk} \in (0,1) \quad \forall j \in w, p \in P, t \in T, u \in U, \tag{12}$$

$$A_{tj}^{e}, A_{tj}^{n} \geq 0 \quad \forall j \in w, p \in P, t \in T. \tag{13}$$

Equation (1) represents the objective function of the model. The objective function includes minimizing fixed ordering costs, transportation, variable ordering costs, inventory maintenance costs, shortage costs, fixed cost of new facility construction, fixed cost of closing the existing facility, cost of increasing facility capacity, and operating cost of the active facility. Equation (2) states that if it is activated in one of the facilitation periods, it should not be closed until the end of the period. Equation (3) is related to increasing the capacity of new facilities in each period and building capacity in the new facilities that are being built. Due to this limitation, the capacity of the facility can be increased if the facility is active during that period. Also, if a facility is activated in any period, one of the capacity levels must be allocated. Equation (4) states that the capacity of existing facilities can be increased if the existing facility remains active until the end of the period. Equations (5) and (6) carry out capacity planning for existing and constructed facilities in each period. The facilitation capacity in each time period is equal to the amount of capacity added in the desired period and the amount of capacity transferred from the previous period. Equation (7) states that each point of demand in each period for each product must be assigned to exactly one of the active facilities. Equations (8) and (9) state that a customer can be assigned to a facility over a period of time if the facility is active during that period. Equations (10) and (11) are related to the facility capacity constraints in each period. Equations (12) and (13) show the type of each decision variable.

3.2.5. Solution Method. In this research, in order to deal with the uncertainties in the cost parameters and the amount of customer demand, the Jimenez possibility method [35] has been used due to its high efficiency. The fuzzy method of Jimenez et al. is programmed based on the expected value and the expected game. Due to the efficiency and computational simplicity, the triangular fuzzy distribution method has been used to deal with the uncertain parameters of the model. Assuming ξ is a triangular fuzzy number, the membership function of this fuzzy number μ(x) is defined as follows:

$$\mu_{\xi}(x) = \begin{cases} f_{\zeta}(x) = \dfrac{x - \zeta^{p}}{\zeta^{m} - \zeta^{p}} & if\ \zeta^{p} \leq x \leq \zeta^{m} \\ 1 & if\ x = \zeta^{m} \\ g_{\zeta}(x) = \dfrac{\zeta^{0} - x}{\zeta^{0} - \zeta^{m}} & if\ \zeta^{m} \leq x \leq \zeta^{0} \\ 0 & if\ x \leq \zeta^{p}\ or\ x \geq \zeta^{0} \end{cases} \tag{14}$$

Expected income (EI) and trigonometric fuzzy numbers are obtained from equations (15) and (16):

$$\begin{aligned} EI(\xi) &= \left[E_1^{\zeta} E_2^{\zeta}\right] = \left[\int_0^1 f_{\zeta}^{-1}(x)dx \int_0^1 g_{\zeta}^{-1}(x)dx\right] \\ &= \left[\frac{1}{2}\left(\zeta^{p} + \zeta^{m}\right)\frac{1}{2}\left(\zeta^{0} + \zeta^{m}\right)\right], \end{aligned} \tag{15}$$

$$EV(\xi) = \frac{E_1^{\zeta} + E_2^{\zeta}}{2} = \frac{\zeta^{p} + 2\zeta^{m} + \zeta^{0}}{4}. \tag{16}$$

Also, for the fuzzy number pairs $\tilde{a}$ and $\tilde{b}$, the degree to which $\tilde{a}$ is greater than $\tilde{b}$ is given in Equation (17):

$$\mu_M(x) = (a\%, b\%) = \begin{cases} 1 & if\, E_1^a > E_2^b \\ \dfrac{E_2^a - E_1^b}{E_2^a - E_1^b - \left(E_2^b - E_1^a\right)} & if\, E_1^a \in \left[E_1^a - E_2^b E_2^a - E_1^b\right] \\ 0 & if\, E_2^a > E_1^b \end{cases} \tag{17}$$

$\mu_M(a\%, b\%) \geq \alpha$ means that at degree α, a greater % is equal to b% and is defined as a% ≥_α b%. In addition, for a pair of fuzzy numbers $\tilde{a}$ and $\tilde{b}$ which is equal to $\tilde{b}$, can say: $\tilde{a} \geq \tilde{b}, \tilde{a} \leq \tilde{b}$. Now consider the following fuzzy mathematical programming model in which all parameters are considered as fuzzy numbers.

$$\begin{aligned} &\min z = cx \\ &a_i x \geq b_i x\; i = 1, \ldots, l \\ &a_i x = b_i x\; i = l+1, \ldots, m \\ &x \geq 0. \end{aligned} \tag{18}$$

According to the Jimenez method [35], Equations (19) and (20) can be presented as the counterpart formulation of uncertain constraints.

$$\frac{E_2^{a_i x} - E_2^{b_i}}{E_2^{a_i x} - E_1^{b_i} - \left(E_1^{a_i x} - E_2^{b_i}\right)} \geq \alpha, \quad i = 1, \ldots, l \tag{19}$$

$$\frac{\alpha}{2} \leq \frac{E_2^{a_i x} - E_2^{b_i}}{E_2^{a_i x} - E_1^{b_i} - \left(E_1^{a_i x} - E_2^{b_i}\right)} \leq 1 - \frac{\alpha}{2}. \quad i = l+1, \ldots, m \tag{20}$$

Now according to Equations (18)–(20), the following formulation can be presented.

$$\left[(1-\alpha)E_2^{a_i} + \alpha E_1^{a_i}\right]x \geq (1-\alpha)E_1^{b_i} + \alpha E_2^{b_i}, \quad i = 1, \ldots, l \tag{21}$$

$$\left[\left(1 - \frac{\alpha}{2}\right)E_1^{a_i} + \frac{\alpha}{2}E_2^{a_i}\right]x \leq \left(1 - \frac{\alpha}{2}\right)E_2^{b_i} + \frac{\alpha}{2}E_1^{b_i}, \quad i = l+1, \ldots, m \tag{22}$$

$$\left[\left(1 - \frac{\alpha}{2}\right)E_2^{a_i} + \frac{\alpha}{2}E_1^{a_i}\right]x \geq \left(1 - \frac{\alpha}{2}\right)E_1^{b_i} + \frac{\alpha}{2}E_2^{b_i}, \quad i = l+1, \ldots, m \tag{23}$$

$$\begin{aligned} &\min EV(c\%)x \\ &\left[(1-\alpha)E_2^{a_i} + \alpha E_1^{a_i}\right]x \geq (1-\alpha)E_1^{b_i} + \alpha E_2^{b_i}\; i = 1, \ldots, l \\ &\left[\left(1 - \frac{\alpha}{2}\right)E_1^{a_i} + \frac{\alpha}{2}E_2^{a_i}\right]x \leq \left(1 - \frac{\alpha}{2}\right)E_2^{b_i} + \frac{\alpha}{2}E_1^{b_i} \\ &i = l+1, \ldots, m \\ &\left[\left(1 - \frac{\alpha}{2}\right)E_2^{a_i} + \frac{\alpha}{2}E_1^{a_i}\right]x \geq \left(1 - \frac{\alpha}{2}\right)E_1^{b_i} + \frac{\alpha}{2}E_2^{b_i} \\ &i = l+1, \ldots, m \end{aligned} \tag{24}$$

According to the Jimenez [35] method, the possibilistic model of multiproduct presented to redesign the supply chain network can be converted as follows:

$$
\begin{aligned}
MinZ = & \sum_{t\in T_L}\sum_{j\in w^n}\sum_{u}\left(\frac{FC_{tj}^{up}+2FC_{tj}^{um}+FC_{tj}^{uo}}{4}\right)y_{tj}^{nu}+\sum_{t\in T_L}\sum_{j\in w^e}\left(\frac{SC_{tj}^{p}+2SC_{tj}^{m}+SC_{tj}^{o}}{4}\right)Y_{tj}^{e}\\
& -\sum_{j\in w^e}\left(\frac{SC_{tj}^{p}+2SC_{tj}^{m}+SC_{tj}^{o}}{4}\right)\sum_{t\in T_L}Y_{tj}^{e})+\sum_{t\in T_L}\sum_{j\in w}\sum_{k\in k_j}\left(\frac{IC_{tjk}^{p}+2IC_{tjk}^{m}+IC_{tjk}^{o}}{4}\right)U_{tjk}\\
& +\left(\sum_{w}\sum_{p}\sum_{t}\sum_{c}\left(\sqrt{2\left(\theta fo_{wtp}+\beta g_{wtp}\right)\left(\frac{\mu_{ctps}^{o}+2\mu_{ctp}^{m}+\mu_{ctp}^{p}}{4}\right)Z_{wctps}\theta h_{wtp}-\frac{\theta h_{wtp}\left(\xi_0\left(\mu_{ctps}^{o}+2\mu_{ctp}^{m}+\mu_{ctp}^{p}/4\right)Z_{wctp}\right)^2}{\theta h_{wtp}+\xi_{tp}}}\right.\right.\\
& \left.\left.\cdot\sqrt{\frac{\xi_{tp}}{\theta h_{wtp}+\xi_{tp}}}\right)+\theta\sum_{w}\sum_{p}\sum_{t}\sum_{c}\left(\frac{\theta h_{wtp}\xi_0\left(\mu_{ctps}^{o}+2\mu_{ctp}^{m}+\mu_{ctp}^{p}/4\right)Z_{wctp}}{h_{wtp}+\xi_{tp}}\right)\right)\\
& +\left(\theta\sum_{w}\sum_{p}\sum_{t}\sum_{c}Z_{wctp}\left(\frac{\mu_{ctps}^{o}+2\mu_{ctp}^{m}+\mu_{ctp}^{p}}{4}\right)a_{wtp}\right.\\
& \left.+\beta\sum_{w}\sum_{p}\sum_{t}\left(h_{wtp}Z_a\sqrt{L_{wt}^{p}\left(\sum_{c}\delta_{cp}^{t}Z_{wctp}\right)\sum_{w}\sum_{p}\sum_{t}\sum_{c}Z_{wctp}\left(\frac{\mu_{ctps}^{o}+2\mu_{ctp}^{m}+\mu_{ctp}^{p}}{4}\right)a_{wtp}}\right)\right),
\end{aligned}
\tag{25}
$$

$$
\sum_{c}\sum_{p}Z_{jcpt}\left(\left(1-\frac{\alpha}{2}\right)\left(\frac{\mu_{ctp}^{p}+\mu_{ctp}^{m}}{2}\right)+\left(\frac{\alpha}{2}\right)\left(\frac{\mu_{ctp}^{o}+\mu_{ctp}^{m}}{2}\right)\right)\leq A_{tj}^{n}, \tag{26}
$$

$$j\in w^n, p\in P, t\in T$$

$$
\sum_{c}\sum_{p}Z_{jcpt}\left(\left(1-\frac{\alpha}{2}\right)\left(\frac{\mu_{ctp}^{p}+\mu_{ctp}^{m}}{2}\right)+\left(\frac{\alpha}{2}\right)\left(\frac{\mu_{ctp}^{o}+\mu_{ctp}^{m}}{2}\right)\right)\leq A_{tj}^{e}, \tag{27}
$$

$$
j\in w^e, p\in P, t\in T. \tag{28}
$$

Other constraints are the same as constraints (2)–(9) and (12) and (13).

Moreover, in this paper, a correlation method was used to obtain a statistical correlation between two or more random variables. This was done using Statistica software, which allowed calculating the Pearson's correlation coefficient, considered below. First, let us consider the concept of correlation analysis. It refers to a method for processing statistical data that measure the tightness of the relationship between two or more variables. A significant correlation between two random variables always evidences some statistical relationship in a given sample, but this relationship does not necessarily have to be observed for another sample and has a cause-and-effect nature.

To analyze the data and interpret the description of the correlation coefficient values, the data in Table 1 are used.

Let $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ be a sample of n observations of a pair of variables (X, Y). The sample correlation coefficient r is defined as

$$
r=\frac{\sum_{i=1}^{n}\left(X_i-\overline{X}\right)\left(Y_i-\overline{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i-\overline{X}\right)^2\sum_{i=1}^{n}\left(Y_i-\overline{Y}\right)^2}}, \tag{29}
$$

where $\overline{X}, \overline{Y}$ are the sample averages defined as follows:

$$
\overline{X}=\frac{1}{n}\sum_{i=1}^{n}X_i, \overline{Y}=\frac{1}{n}\sum_{i=1}^{n}Y_i. \tag{30}
$$

Further, based on the above methodology, a statistical analysis of the data provided by the UK governance is carried out. Methods such as induction, deduction, analysis, comparison, generalization, and concretization are also used.

Table 1: The correlation coefficient values and their interpretation [32].

The values of the correlation coefficient r	Interpretation
$0 < \Gamma \leq 0.2$	Very weak correlation
$0.2 < \Gamma \leq 0.5$	Weak correlation
$0.5 < \Gamma \leq 0.7$	Average correlation
$0.7 < \Gamma \leq 0.9$	Strong correlation
$0.9 < \Gamma \leq 1$	Very strong correlation

Table 2: Parameter values of the mathematical model.

fc_{tj}^{u}	Uniform (100,120)	Q_j^e	Uniform (200,300)
sc_{tj}	Uniform (90,100)	μ_{cpt}	Uniform (120,130)
ic_{tjk}	Uniform (20,30)	l_{wt}^{p}	Uniform (5,12)
oc_{tj}	Uniform (10,15)	$\sigma_{cp}^{2,t}$	Uniform (10,30)
sf_{tj}	Uniform (10,15)	β	Uniform (0.1,0.3)
fo_{wtp}	Uniform (8,12)	θ, β	Uniform (0.1,0.3)
g_{wtp}	Uniform (5,8)	ξ_0	Uniform (0.3,0.6)
h_{wp}^{t}	Uniform (6,9)	ξ_{tp}	Uniform (0.2,0.5)
a_{twp}	Uniform (10,15)		

4. Numerical Results

In this section, the efficiency of the multiperiod mathematical model presented in order to redesign the warehouse network is discussed. The required data for the parameters of this problem are generated using a uniform distribution. Table 2 shows the important parameters needed to solve the problem.

Finally, the mathematical model is optimized using GAMS software. It is observed that with increasing the level of satisfaction of the decision-maker, the total cost of the supply chain network should increase. The rate of these changes from 0.1 to 0.5 is very significant, and also, from 0.5 to 0.9, changes in the objective function have small fluctuations. The analysis also shows changes in the cost function versus changes in the weight of inventory and shipping costs. As the share of inventory and shipping costs increases from the total costs, the value of the objective function also increases.

4.1. The Influence of Distribution Systems on Technological Innovation. First, to further analyze changes in the level of innovation activity, consider the intensity of distribution allocated to technological innovations in the concerned area as shown in Figure 2.

Based on the presented data, the maximum intensity of distribution of technological innovations in the period from 2011 to 2020 was reached in 2016, amounting to 6%, while the minimum intensity was 3.9% in 2008 and 2016. Technological innovation activity aims to obtain and apply new knowledge to solve technological and engineering problems, ensuring the production and operation of the enterprise as a single effective complex. It includes changes based on the application of scientific and technological progress, the latest technologies, and management tools.

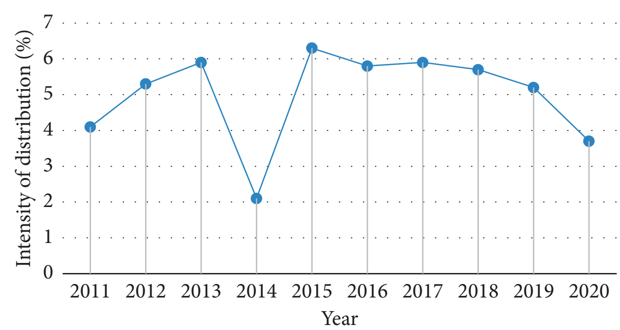

Figure 2: The intensity of expenditures on technological innovations in 2011–2020.

Product innovation activity involves manufacturing products or producing new services or having new characteristics or ways of using them. There are still opportunities to increase the level of product innovation since the proportion of organizations that have implemented innovations remains small.

4.2. Comparison of Implementation Product and Process Innovations on Technological Innovations. An important indicator that characterizes innovation activity is the proportion of organizations that implement product and process innovations. The curves in Figure 3 show these values for the period under review.

The line shows that the maximum percentage of organizations having implemented product innovations for the period under review is 66.7%, reached in 2010. Next, the relationship between the percentage of organizations implementing product innovations and profitability is considered in Table 3.

The correlation analysis has shown that the percentage of supply chain profitability and the intensity of expenditures have an inverse average relationship, indicating that high costs are spent on purchasing and installing new equipment. The inverse relationship is due to the fact that at the beginning of implementation, production decreases and investments increase during the purchase, installation of equipment and personnel training. Further investments are reduced, while the effect of innovation implementation increases because the equipment is installed and running.

4.3. Discussion. During the last two decades, managers have witnessed a period of tremendous global change due to advances in technology, globalization of markets, and new economic and political conditions. With the increase in the number of competitors in the world class, organizations were forced to quickly improve internal processes to remain in the global competition scene. In the 1990s, in parallel with the improvement in production capabilities, industry managers realized that the materials and services received from different suppliers have a significant effect on increasing the organization's capabilities in order to deal with the needs of customers; this, in turn, had a double effect on the organization's focus and supply bases and sourcing

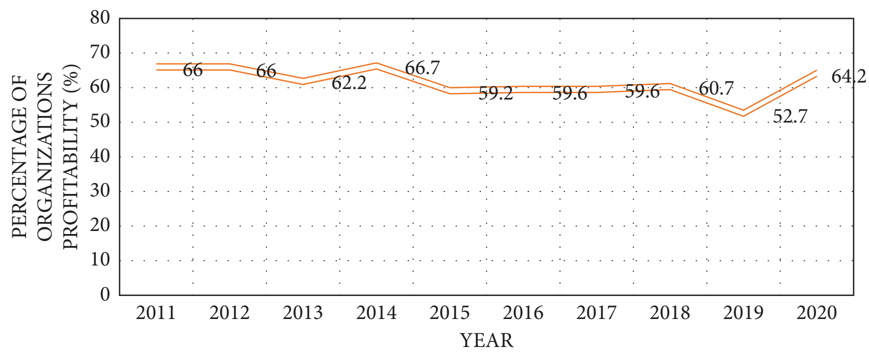

Figure 3: Percentage of organizations having implemented product innovations (%).

Table 3: Correlation analysis of the proportion between supply chain profitability and the intensity of expenditures on technological innovations.

Correlation analysis	
The percentage of supply chain profitability	The intensity of expenditures on technological innovations
66	4.1
66	5.3
62.2	5.9
66.7	2.1
59.2	6.3
59.6	5.8
59.6	5.9
60.7	5.7
52.7	5.2
64.2	3.7
Correlation analysis results	
1.00	−0.51
−0.51	1.00

strategies. Also, the managers realized that it is not enough to produce a product with the right quality. In fact, providing products with the criteria desired by the customer and with the quality and cost desired by them created new management challenges for today's organizations. With such an attitude, the "supply chain" and "supply chain management" approaches came into existence.

The supply chain can be defined as a network of related and interdependent organizations which work together to control, manage, and improve the flow of materials and information from suppliers to end users. The behavior of orders in the supply chain is considered an important issue, which is the main focus of this article. The act of ordering during the supply chain has multiple processes and activities, which indicate the system's efficiency and can be scheduled and require time and resources to perform. Also, the process indicates the performance of the system that causes a logical sequence of activities to realize a predefined goal. A process consists of activities that require resources to be realized. In the process of ordering, orders are made during successive activities that represent the steps required in a certain process. In this regard, the process must be done by spending certain resources and passing through different positions depending on the type of order. It should be noted that the order goes through different routes according to its type. The act of ordering during different stages can have a possible state. When the ordering action is done, its evaluation is done by comparing the goal and the result. As mentioned, the lack of coordination of the result and the goal causes increased costs and loss of customers and the market. This is one of the main challenges in the supply chain. This article seeks to solve this problem or answer this basic challenge. Due to the fact that the ordering process and the arrival of the orders to the final destination are in the form of a queue of orders, the mathematical modeling approach is used to solve the mentioned problem in this article. The presented results show that supply chain optimization can provide comprehensive solutions for managing multiple companies at the same time.

5. Conclusion

The understanding of public service broadcasting, whose main functions are to educate, provide information, and neutrality, has tried to adapt to the competitive conditions brought about by the free market economy on the one hand and to cope with the problems related to financial, technological, and audience demand on the other. Later, it has managed to survive by adopting new accountable features that are pioneers in producing creative, original programs that give importance to the participation of the audience.

In this paper, in order to formulate the role of public demand on distribution systems, a mathematical model is presented to redesign a network of warehouses in a multiperiod, multiproduct model, taking into account the lack of after sales. To date, no studies have been presented to redesign multiperiod, multiproduct supply chain networks, taking into account decisions related to warehouse redesign and lack of backlog. Related decisions include redesigning the chain network, locating new facilities at different strength levels, shutting down nonoptimal existing facilities, expanding the capacity of active facilities over strategic periods, and allocating customers to warehouses. At the same time, decisions related to the optimal economic order quantity for each of the active warehouses in each period have been considered considering the shortage of recovery. Due to the nature of the uncertainty in the parameters of the problem, the uncertainty in the parameters related to the cost and the amount of demand has been considered, and in order to deal with the uncertainties, the Jimenez fuzzy method has been used.

One of the most important managerial insights of this research is that by optimizing the supply chain of urban products, it is possible to have a comprehensive plan for producing and distributing these products in the city. This is despite the fact that the amount of inventory is also managed in different periods, and it is possible to manage the conditions efficiently in emergency situations and when the demand grows sharply.

As a suggestion for future research, we can mention the solution of the proposed mathematical model using metaheuristic algorithms, modeling the problem by considering routing decisions, and using other uncertainty methods to deal with existing uncertainties.

Data Availability

Data are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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