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Destruction Decisions for Managing Excess Inventory in E-Commerce Logistics

Pourya Pourhejazy

Department of Industrial Engineering and Management, National Taipei University of Technology, Taipei 10608, Taiwan; pourya@ntut.edu.tw

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Abstract: The Internet has brought about new possibilities for innovation and radically changed business activities. Internet shopping is a prime example of increasing popularity, which is exacerbated due to the recent pandemic. It is expected that e-commerce will accommodate more than a quarter of the total retail sales worldwide in the next few years. Given the characteristics of e-commerce, inventory management is of paramount importance for an effective and timely response to the online customers' demand. Despite its relevance, the issue of warehouse excess inventory is not sufficiently studied in the operations management literature. This study explores the factors, including sustainability and strategic considerations, that influence the inventory destruction decisions as one of the alternatives for managing excess inventory. Applying the Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, the interrelationships between the decision factors are investigated and the decisive considerations are identified. Overall, the outcomes provide insights for the e-commerce practitioners and offer directions for modeling and managing inventory destruction decisions.

Keywords: inventory management; e-commerce; excess inventory; inventory destruction; decision analysis

1. Introduction

Electronic commerce (e-commerce) has become increasingly important particularly due to its positive environmental impacts in reducing emissions and energy consumption of various means by replacing traditional shopping [1]. In 2019, e-commerce accounted for more than 15 percent of the overall sales worldwide [2] and has seen exponential growth due to the recent pandemic [3,4]. In this situation, staying competitive in the marketplace relies on the e-commerce companies' operational agility [5] and their ability to offer responsive services.

Given the growing number of producers using online platforms to sell their products [6], warehouse management, including the handling and storage of goods between various stages of a supply chain [7] play a significant role in e-commerce operations. E-commerce operating as self-operation model benefits from sales revenue of the products they own [8]. The tight schedules of online retailers make flexibility a critical factor influencing the competitiveness of e-commerce platforms [9]. Considering the large depth and width of the products available in the warehouses, unnecessary excess inventory may negatively influence the operational flexibility, causing longer lead times, additional logistics costs [10], wastes and spoilage [11], and hinders the restock of other goods that may result in demand loss [12].

Inventory management is well-established in the operations management literature. The existing studies are mostly focused on quantitative models, for example, inventory lot-sizing problems [13], capacity and inventory management [14], inventory control models [15], and inventory systems with deterioration [16]. Limited attention has been given to the issue of excess (over) inventory. Retailers may manage the excess inventory from their supply chain network either by returning it to the producer or through liquidation decisions [17]. There are various alternatives to deal with this

operations management problem. Markdown sale of the products maximizes value recovery in the management of returned or unsold products [18]. On the other hand, the company may benefit from non-financial investments, i.e., building strategic partnerships and improving the company's image by gifting the products in marketing campaigns, business-to-business deals, or donations. As the last alternative, destruction of the excess inventory may be necessary to avoid additional expenses and improves operational flexibility by making space for other products. The inventory destruction decisions are, however, complex requiring well-informed decisions considering tangible and intangible outcomes, and a balance of financial and non-financial considerations. Recent articles explored the product deletion decisions from the producers' perspective [19,20]. These researches introduced supply chain operational, competitive, and sustainability considerations for the discontinuation decisions in fast-moving consumer goods production. No studies explored the inventory destruction decisions in e-commerce logistics for dealing with the excess inventory of non-perishable goods. To address this gap, the present research identifies the decision factors pertinent to the inventory destruction decisions in e-commerce environments and explores how these factors influence each other in order to provide directions for modeling and managing inventory destruction decisions as an operational strategic tool. For this purpose, the Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) is applied to explore the interrelationship between the factors influencing the inventory destruction decisions.

The remainder of this manuscript begins with a systematic review of the relevant literature followed by identifying the decision factors involved in the inventory destruction decisions. A case study from e-commerce is then presented to explore the interrelationships between the identified decision factors. Lastly, the manuscript is concluded by providing managerial implications and insights for modeling product management decisions for dealing with e-commerce excess inventory problems.

2. Literature Review

2.1. Literature of the Alternatives for Dealing with Excess Inventory

A systematic literature review is conducted to identify relevant published articles. For this purpose, the following keywords are searched in the title and abstract of the papers using Google Scholar database in two separate rounds: (1) "inventory liquidation" OR "inventory destruction" OR "inventory deletion" OR "inventory removal"; (2) "product destruction" OR "product liquidation". The keywords "product deletion" and "product removal" are not included in our search because they refer to the discontinuation of a brand/product from the production process by the manufacturer [19]; for a detailed review of these papers, we refer the readers to [20]. Overall, a total of 75 articles were initially identified by the search engine. The irrelevant papers were excluded through reviewing the titles at the first step, and the keywords and abstract parts in the second stage; of 16 articles, which were perceived as relevant, the following are considered as the most pertinent for a detailed review.

Reference [21] is one of the first to study markdown liquidation decisions using game theory for pricing under complete information availability. Ref. [22] proposed an Euler-Lagrange theorem-based approach to find the optimal liquidation time and the analytical solution of the optimal liquidation strategy to minimize the utility losing function. Studying the excess inventory in a periodic review stochastic inventory system, Ref. [23] developed a price-dependent demand model and an inventory model to optimize the unit promotional price and liquidation quantity. Ref. [24] developed general dynamic programming and greedy approaches to optimize the inventory liquidation problem. The authors showed that the widely used liquidation strategies are suboptimal and suggested that more sophisticated pricing strategies should be applied for product markdowns. Arguing that a partial sale' strategy comprising the inventory markdowns across different contracts is not optimal, Ref. [25] developed an Approximate Dynamic Programming (ADP) approach to investigate the optimal liquidation strategy. Ref. [17] developed a dynamic programming approach for maximizing retailers' profit through joint replenishment, pricing, and removal decisions. Most recently, Ref. [26] developed

computational strategies for the inventory liquidation problem, characterizing it by a retailer disposing of a fixed volume of end-of-cycle products over a time period with a focus on the inherent stochasticity.

These papers considered the pricing models for markdown decisions as a major inventory liquidation alternative, addressing the economic means of inventory liquidation decisions. Inventory destruction decisions as the other possible alternative have received limited attention. A systematic approach to analyzing broader financial and non-financial considerations involved in inventory destruction decisions is of high significance to avoid myopic decisions. Inspired by this research need, this study explores the inventory liquidation decisions and sheds light on the impact of non-financial aspects.

2.2. Factors Influencing Inventory Destruction Decisions in E-Commerce

Inventory destruction decision is a multi-functional managerial practice, often caused due to applying inaccurate forecast techniques [27], which is usually initiated by category managers in the e-commerce environments. Inventory destruction decisions are particularly important in industries such as e-commerce wherein there is a wide variety of products and bulky assortment sizes [28]; they are also relevant for managing inventories with short life cycles [29]. The destruction decisions should be based on the analysis of the tangible and intangible outcomes to ensure the best managerial course of action. Myopic financial perspectives may result in adverse impacts in the long term [20]. Although inventory destruction is usually a reactive managerial practice, multi-faceted operational factors are required to ensure sustainable outcomes for such strategic decisions [30]. Given the vital role of *cost*, *quality*, *flexibility*, and *delivery* as strategic performance competencies in organization decision-making [31], they are used to identify the factors influencing inventory destruction decisions. Beyond these considerations, this study extends to include sustainability and strategic aspects into inventory destruction decisions.

Logistics activities associated with warehousing and transportation of products account for much of the e-commerce operational *cost* [32]. Given that handling excess inventory imposes additional costs, destructing them can be beneficial to prevent further losses [33]. However, there are situations in which inventory destruction is costly due to the complex structure of the product or regulatory reasons. Besides, some products are of high monetary value, which makes it less likely to think of destructing them. In these situations, other alternatives for dealing with excess inventory may be preferred.

Quality refers to the product's features that drive satisfaction among the targeted customers of the company [34]; it has a direct impact on the product management decisions [35]. If the products are defective, outdated, or perceived as a poor-quality product, destruction decisions may be beneficial because they not only avoid incurring additional costs but also help prevent hurting the brand image or the e-commerce company's reputation. There are circumstances where destruction decisions may negatively influence a reputable brand; in this situation, the excess inventory should be sent back to the producer to avoid possible legal actions [36].

Flexibility is defined as the firm's ability to cope with uncertainties while ensuring minimal losses in time and cost [37]. *Flexibility* is of particular importance in highly dynamic markets to effectively conform to the changes [38]. Given that redundant capacity improves *flexibility* of the operations [39], the physical limitations associated with the warehousing activities make it necessary to get rid of excess inventories to be able to respond quickly to demand surges for other products or the introduction of a new product while keeping the operational costs at its minimum.

As a strategic performance competency, *delivery* is defined as the company's ability to satisfy the customers' needs responsively [31]. Inventory shortage or the absence of commodity products in the product list of an e-commerce platform makes the customer use the competitor's platform; in addition to the lost sale, this may result in losing the customer's loyalty for their next purchases. Having substitutes, i.e., the products intended to serve the same functionality and purpose [20,40–42], helps ensure that destructing certain products does not adversely impact the e-commerce company's ability to fulfilling possible customer needs. As a long-term consideration, partnership with the producers is of

paramount significance to ensure low cost, high quality, high flexibility, and responsiveness in providing a responsiveness platform for online shoppers. In certain cases, the destruction decision may damage the trust and impose risks for the continuation of supplying other products provided by the same producer. Given that trust and commitment are crucial for maintaining customers [43], partnership with the business-to-business customers may suffer by inattentive inventory destruction decisions.

In addition to the above competencies, sustainability factors are crucial to ensure that the decision outcomes are favorable in the long term. As prime examples of an unsustainable decision, the destruction of some products may impose negative impacts on the environment and health due to the resulting pollutants [44]. Besides, the destruction of certain products may impose negative social impacts, i.e., hurt the companies' image, cause boycotts, or legal actions due to political, nationalistic, and religious values associated with the products. In these situations, inventory destruction decision is not a sustainable alternative for dealing with the excess inventory problem. Overall, considering social and environmental sustainability helps establish a balance of short- and long-term considerations for well-informed inventory destruction decisions. Table 1 provides a list of these factors for inventory destruction decisions in e-commerce environments.

Table 1. Factors for excess inventory destruction decisions in e-commerce.

Identifier	Factor	Explanation
PM	Profit Margin	High inventory holding costs limit the profit margin. In this situation, the low monetary value of the product increases the likelihood of inventory destruction decisions.
BR	Brand Reputation	If markdowns and gifting of a product negatively influence the brand, inventory destruction decisions may be a better option to avoid reputational damages.
SP	Strategic Partnerships	Producers expect sales, and the destruction of an item may damage the trust and negatively influence the long-term partnership between the producer and the e-commerce company.
EH	Environmental and Health Impacts	Destruction of certain products may impose negative impacts on the environment, and health, for example, due to the landfill of hazardous elements among the other pollutions.
OP	Obsolete Product	Products of fast-changing markets, i.e., the fashion and technological trends, may be outdated and unappealing to the customer, hence, can be candidates for destruction decisions.
RN	Reallocation Needs	In occasions of demand surge for other products or the introduction of a new product, destruction decisions may be an option to make space in the warehouse for storing new items.
PS	Product Substitution	If there are alternatives to an unsold item, which can serve the same purpose for the customers, it is more likely that the e-commerce company considers destruction for a poorly performing item.
DC	Destruction Cost	Product features, i.e., complex structure or regulatory reasons, may make destruction an expensive option compared to other alternatives for dealing with the excess inventory.
DR	Defects and Returns Rate	Product return imposes additional logistics costs; a high return record is a negative sign for the future performance of the same product. Besides, if the products are low quality or defective and cannot be fixed or improved, the other alternatives of dealing with excess inventory may not be applicable, hence, a destruction decision may be inevitable.
SI	Social Impact of the Product	The positive social impact of a product, like the religious, political, and nationalistic values or the green image the product creates, make inventory destruction decisions very unlikely.

3. Data Collection and Processing

3.1. Case Description

An online shopping platform with over 1 million online daily visitors is considered as the case study. The operational network of the case company is based on three warehouses, allowing shoppers to purchase the items that either belong to a seller or are owned by the e-commerce company. With a monthly turnover of over 56 million USD in 2019, the company has over 700,000 items, including food, furniture, clothing, and consumer electronics available for sale, and is planning to expand the products' width and depth gradually. Therefore, dealing with excess inventory is a major operational decision at the case company. Data collection began with confirming the identified decision factors in the literature review section with the managers; except for SI (social impact), which is perceived as poorly relevant considering the products they provide and the market environment wherein the company operates, therefore, the rest were chosen to proceed to the decision analysis phase. Next, a questionnaire was developed based on these nine factors to three category managers of the company. Data processing using the Fuzzy DEMATEL method is presented next.

3.2. DEMATEL Data Processing

The DEMATEL method was introduced by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva [45] to study the complicated and intertwined problems. The main goal of DEMATEL is to understand system underpinnings, identify key factors through analyzing the interrelationships among factors, and determine the cause and effect relations [46].

Relying on experts' opinions, which are often subjective, makes the basic DEMATEL prone to uncertainty, imprecision, and vagueness. That is, the observations may be filtered through their perceptions despite using factual and objective data. Fuzzy set theory [47] is used to alleviate the above shortcomings. The three-step computational procedure of Fuzzy DEMATEL is summarized below.

Step 1. Preparation of the direct-relation matrix (DRM). Given the relationship value between factors i and j, considering expert n's opinion, the following five linguistic terms are considered to generate crisp values: no influence, very low influence, low influence, high influence, and very high influence, that are associated with fuzzy triplets of (0, 0, 0.25), (0, 0.25, 0.5), (0.25, 0.5, 0.75), (0.5, 0.75, 1.0), and (0.75, 1.0, 1.0), respectively, representing lower- (fl_{ij}^n), mid- (fm_{ij}^n) and upper-bound (fu_{ij}^n) parameters of an interval scale. These values are first normalized and transformed to the double-parameter fuzzy equivalent. The crisp values associated with each expert are then estimated. Finally, the overall DRM can be obtained by (weighted) averaging of the resulting crisp values.

Step 2. Preparation of the total-relation matrix (TRM). This step begins with normalizing DRM by dividing every element by the largest column-and-row summation value. Given the normalized direct-relation matrix (NDRM), TRM is calculated by multiplying NDRM and the reverse of its difference from the identity matrix, that is $TRM = NDRM(1 - NDRM)^{-1}$.

Step 3. Cause-effect and prominence analysis. To analyze the total relation, the factors can be categorized into cause and effect groups. Given m factors in TRM, the summation of rows determines the overall influence a factor dispatches (D_i), and the summation of values under each column shows the overall influence a factor receives (R_i). Having that said, the prominence value ($D_i + R_i$) for factor i defines the extent of its involvement and the net-causation value ($D_i - R_i$) characterizes the sort of its involvement in the decision environment. That is, a factor with a positive net-causation is an influencer, while a negative value shows that the factor is significantly impacted by other factors. Besides, the higher the prominence value is, the greater is the factor's contribution to the decision.

3.3. Results Analysis

Given the direct relations in Tables 2–4, which are stated in linguistic terms, the three-step procedure presented in Section 3.2 is considered to process data and obtain the TRM. To identify the total relations with a significant magnitude, a threshold of average plus one standard deviation of the TRM values is considered, as suggested by [20]. It is observed that Environmental and Health Impact imposes the most significant influence on the financial factors, i.e., Profit Margin and the Destruction Cost. The Strategic Partnerships appeared to impose a significant impact on the Profit Margin, particularly in the long term. Other significant interrelations are differentiated in bold font in Table 5.

Table 2. Direct relation data obtained from expert 1.

DRM-I	PM [1]	BR [2]	SP [3]	EH [4]	OP [5]	RN [6]	PS [7]	DC [8]	DR [9]
PM	-	L	VH	N	H	H	H	L	VH
BR	VH	-	N	H	H	N	H	N	N
SP	VH	N	-	N	N	N	H	N	N
EH	VH	VH	H	-	L	H	N	VH	H
OP	VH	N	N	L	-	N	H	H	H
RN	N	N	N	N	L	-	L	H	H
PS	H	H	H	N	N	N	-	N	N
DC	H	N	N	VH	VH	L	VH	-	VH
DR	H	N	N	N	L	H	H	H	-

[1]: Profit Margin, [2]: Brand Reputation, [3]: Strategic Partnership, [4]: Environmental and Health Impacts, [5]: Obsolete Product, [6]: Reallocation Needs, [7]: Product Substitution, [8]: Destruction Costs, [9]: Defective and Returned Item.

Table 3. Direct relation data obtained from expert 2.

DRM-II	PM [1]	BR [2]	SP [3]	EH [4]	OP [5]	RN [6]	PS [7]	DC [8]	DR [9]
PM	-	N	VH	N	VH	H	L	VH	VH
BR	L	-	L	H	H	N	H	N	N
SP	VH	L	-	L	H	N	L	H	H
EH	H	H	H	-	H	L	N	VH	N
OP	VH	H	N	VL	-	VH	L	H	H
RN	VH	N	N	N	H	-	L	VH	H
PS	H	H	VL	N	H	L	-	N	N
DC	VH	N	H	VH	L	VH	N	-	L
DR	VH	N	H	N	VL	H	VL	VH	-

[1]: Profit Margin, [2]: Brand Reputation, [3]: Strategic Partnership, [4]: Environmental and Health Impacts, [5]: Obsolete Product, [6]: Reallocation Needs, [7]: Product Substitution, [8]: Destruction Costs, [9]: Defective and Returned Item.

Table 4. Direct relation data obtained from expert 3.

DRM-III	PM [1]	BR [2]	SP [3]	EH [4]	OP [5]	RN [6]	PS [7]	DC [8]	DR [9]
PM	-	VL	VH	VH	VH	H	H	VH	VH
BR	VH	-	N	VH	H	N	H	N	VH
SP	VH	L	-	H	L	N	H	H	VH
EH	VH	VH	VH	-	H	VL	N	VH	H
OP	VH	L	N	H	-	N	H	VH	H
RN	L	N	N	L	L	-	L	H	H
PS	VH	VH	H	N	N	N	-	N	N
DC	VH	N	VH	VH	VH	L	N	-	VH
DR	H	H	H	H	L	L	L	H	-

[1]: Profit Margin, [2]: Brand Reputation, [3]: Strategic Partnership, [4]: Environmental and Health Impacts, [5]: Obsolete Product, [6]: Reallocation Needs, [7]: Product Substitution, [8]: Destruction Costs, [9]: Defective and Returned Item.

Table 5. Total relationship matrix for inventory destruction decision factors.

TRM	PM [1]	BR [2]	SP [3]	EH [4]	OP [5]	RN [6]	PS [7]	DC [8]	DR [9]
PM	0.0738	0.0583	**0.1316**	0.0723	**0.1347**	0.1069	0.1086	0.1315	**0.1446**
BR	**0.1255**	0.0285	0.0515	0.1012	0.1053	0.0304	0.0999	0.0425	0.0687
SP	**0.1423**	0.0591	0.0358	0.0687	0.0800	0.0336	0.0956	0.0866	0.0940
EH	**0.1526**	0.1125	0.1176	0.0432	0.1164	0.0845	0.0510	**0.1431**	0.1032
OP	**0.1482**	0.0679	0.0439	0.0805	0.0461	0.0680	0.0989	**0.1212**	0.1141
RN	0.0926	0.0237	0.0324	0.0438	0.0883	0.0276	0.0757	0.1117	0.1041
PS	0.1117	0.0937	0.0768	0.0249	0.0543	0.0349	0.0270	0.0286	0.0317
DC	**0.1501**	0.0369	0.0972	**0.1254**	**0.1264**	0.1005	0.0749	0.0579	**0.1293**
DR	**0.1306**	0.0498	0.0820	0.0570	0.0831	0.0928	0.0835	**0.1186**	0.0444

[1]: Profit Margin, [2]: Brand Reputation, [3]: Strategic Partnership, [4]: Environmental and Health Impacts, [5]: Obsolete Product, [6]: Reallocation Needs, [7]: Product Substitution, [8]: Destruction Costs, [9]: Defective and Returned Item.

Expectedly, Profit Margin has been identified as a decision factor with the highest influence. As shown in Table 6, Obsolete Product, Defective and Returned Items, and Product Substitution are the other factors that receive more influence than dispatching influence on the other factors in the decision network. The results are supportive of Profit Margin as the most prominent factor, and the Environmental and Health Impact as the factor that exerts the highest net-influence in the decision-making process, both directly and indirectly. Given that the costs of inventory destruction are mostly caused by the regulatory measures, new policies and restrictive measures applied by the local authorities help revise the unsustainable approaches.

Table 6. Net-causation and prominence values for inventory destruction decision factors.

Identifier	Factor	Prominence	Net-Causation
PM	Profit Margin	2.0899	−0.1654
BR	Brand Reputation	1.1839	0.1231
SP	Strategic Partnership	1.3645	0.0270
EH	Environmental and Health Impact	1.5411	0.3071
OP	Obsolete Product	1.6236	−0.0458
RN	Reallocation Needs	1.1792	0.0206
PS	Product Substitution	1.1986	−0.2312
DC	Destruction Costs	1.7406	0.0570
DR	Defects and Returns Rate	1.5760	−0.0924

3.4. Discussion

The following academic and practical implications can be extrapolated from the study. The responsiveness of the e-commerce service provider plays a significant role to establish strategic fit in the supply chain. In order for a company to adjust its supply chain capabilities in accordance with the competitive strategy, there must be harmony between various functions [48]. The notable value of inventory destruction as an operational strategic tool is that it enables the distributors to adhere to a responsive operational strategy with making space for fast-moving items and the products targeting a market with high implied demand uncertainty. Inventory destruction decisions in response to urgent reallocation needs may result in myopic decisions, hence, a forward-looking proactive destruction decision may be necessary to make buffer space for unpredictable situations, like a surge in the demand of a certain product, for example, masks and personal production equipment and ventilators in the recent pandemic. For this purpose, time-to-implement is a critical aspect of inventory destruction such that it is not too early to destruct the inventory of a certain product and miss possible chances for alternative approaches like markdowns and gifting, and not too late that keeping the inventory results in further losses which, in turn, may result in a reactive and hasty myopic decision.

The results suggested that non-financial perspectives are crucial for making well-informed inventory destruction decisions. Considering the sequential effect [20] of these factors on the financial aspect is as important as considering the temporal state when evaluating a destruction candidate in terms of the studied decision factors. That is, the non-financial factors drive changes in the future state of the financial performance of the product in the long term; considering such aspects may help avoid reactive destruction decisions. For example, a product with a current average financial performance is susceptible to performance degradation if the factors with high impact on the profit margin, i.e., brand reputation, strategic partnership, environmental and health impacts, and the defects and returns rate are perceived as negative in the current evaluation of the product.

Overall, markdown sale of the excess inventory is the most economically viable alternative to inventory destruction. Alternatively, the company may benefit from gifting the products in marketing campaigns or donations non-financially. In circumstances where the above alternatives are not applicable, sending the excess inventory to the authorized recyclers and processors may be the best alternative to inventory destruction to reduce the adverse impacts of non-standard destruction approaches. Unsustainable destruction approaches such as open burning, strong acid corrosion, and discarding useless substances cause serious environmental issues [49,50] and health risks [51,52]. In addition to the above sustainability issues, there may be a risk to outsource the inventory destruction process to unknown entities where the items may end up being sold in the gray market or used in inappropriate ways. These issues may result in long-term adverse consequences for the brand, hence, need to be dealt with carefully.

In addition to the practical implications, there is room for refining the available inventory models based on the results of this study. The existing research largely focuses on analytical tools for markdown decisions, for example, using game theory or pricing/revenue management models. These studies should account for the costs imposed by possible destruction decisions if the products are not sold out under markdowns. That is, the alternatives to markdown decisions should be indirectly involved to make well-informed markdown decisions as the most favorable alternative for dealing with excess inventory. Such models can be particularly useful for products with a short life cycle, like fashion products where the time factor is of certain cachet.

Correlation between products is another aspect that needs to be considered in the existing analytical decision aid tools, particularly the models for periodic review inventory systems. For example, the destruction of a product that does not have a substitute, particularly if the producer's targeted segment are the customers sensitive to product availability and response time, may result in unwanted situations in the long term, i.e., in terms of the competitive forces [42]. Besides, the current models can be revised to address the situations where the target products for inventory destruction decisions complement each other and the spare parts of discontinued products. The next implication comes from selecting the optimal liquidation strategy and implementation time. Taking recoverable items as an example, the features like high cost and low demand [53] as well as deterioration with time make destructing them an option. However, with the circular economy encouraging *R*-imperatives [54], burying or burning the products, which is often the case for fashion houses, are the least appealing alternatives for dealing with excess inventory through destructing them. Instead, R-imperatives, like recycling and reuse, should take place. Some of the decision factors introduced in this study can be beneficial in defining a clear boundary between burying/burning and remanufacturing, refurbishing, or repurposing decisions. Besides, the existing analytical tools, more particularly the models based on Multi-Echelon Technique for Recoverable Item Control, like [55], can be revised by including the non-financial aspects introduced in this study to account for their sequential effect on the financial outcome. Given that the introduced factors are both qualitative and quantitative, the presence of uncertainty, and significant interaction between the factors, fuzzy-based approaches are useful complementary tools to improve the utility functions of the existing inventory models. Alternatively, some of the soft factors introduced in this study can be used in the trade-off for selecting

the best alternative from the Pareto-frontier of optimal solutions within posterior and interactive preference articulations.

The final implication comes from considering the push/pull view of the supply chain processes and exploring the issue of inventory ownership using game theory models while considering some of the aspects introduced in this study. In so doing, one can study the best push/pull boundary bearing in mind the possibility of facing the excess inventory problem.

4. Concluding Remarks

As one of the alternatives for dealing with the excess inventory issue, destruction decisions require a set of financial and non-financial considerations and a balance of short- and long-term considerations. Mere focus on myopic financial aspects may negatively impact the company's image and competitiveness. This manuscript explored the underpinnings of inventory destruction decisions, which have received limited attention in the operations management literature. Although the financial consideration, i.e., profit margin, was confirmed as the most prominent factor influencing the inventory destruction decisions, the sustainability consideration, and the environmental and health impact, appeared to be the factor with highest net influence; this factor is expected to have a long-term influence on the decision outcomes and has to be considered in inventory destruction decisions. It is also shown that competitive factors, like the presence of substitute products and strategic partnerships, are of high relevance to make well-informed inventory destruction decisions.

Despite using literature and managerial insights, there are certain limitations to this study. The first limitation is that a single case company is considered. That is, the studied decision factors are suitable for general e-commerce decision environments; future studies with other contexts may require different or additional factors in accordance with industry and market characteristics. In the case study, the social sustainability aspect of inventory destruction decisions was not recognized as a highly relevant factor, but it may cause a great deal of impact in other situations. Future studies may explore the impact of religious, political, and nationalistic views on product deletion and inventory destruction decisions. Risks are other aspects to consider when approaching inventory destruction decisions. As for the next recommendation for future research, product- and industry-specific environmental factors can be studied to provide insights for decision-makers regarding international regulations and regulatory compliance pertinent to destruction decisions. The number of respondents, particularly the fact that they did not contain the managers across various disciplines, is the other limitation of this study that can be addressed in future works. Finally, future research can explore other alternatives for dealing with the excess inventory issue; for example, exploring the factors involved in the markdown, salvation, and donation decisions is a worthwhile research topic to pursue.

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