How Can e-Grocers Use Artificial Intelligence Based on Technology Innovation to Improve Supply Chain Management?

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Abstract. The digital transformation among grocery sales is in full swing. However, some retailers are struggling to adapt to technological innovation in the grocery industry to achieve digital excellence. The purpose of this article is to analyse artificial intelligence systems applied in e-commerce that could be implemented in online grocery sales. Unlike other online businesses, grocery sales face logistical challenges that differentiate them, such as fresh product conservation and tight delivery times. Through a literature review, this study aims to provide researchers and practitioners with a starting point for the selection of technological innovation to solve e-grocery problems.

Keywords: artificial intelligence; digital transformation; e-commerce; grocery sales; applied systems.

1 Introduction

The online sale of food products is gaining considerable commercial interest and generating numerous business opportunities. Traditional grocery sales must adapt to the digital transformation where online sales present great difficulties not identified in other sectors [1,2]. In addition to the logistical efforts required to preserve the quality of perishable products [3], complications are exacerbated by tight delivery times [4]. All these difficulties give rise to the need for artificial intelligence (AI) systems to tackle the digital transition existing in the online grocery retail trade [5].

AI systems deal with computer programs that possess own decision-making capability to solve problems in the areas of representation of knowledge, learning, prediction, reasoning and perception [6]. The first AI system applied to the online channel of grocery sales was developed as a support for decision-making [7]. Grocery sellers can select the most suitable transport operating system in terms of cost, distance and time through this tool. That research line was followed by another author who combined an agent-based simulation with inventory optimization [8], in which the use of geographic network data reduces transport distances. One year later, the same author completed the previously developed system by presenting a simulation and optimization-based decision support system [9]. The computational experiments

are able to model demand patterns and logistics processes by integrating data on the shelf life and preferences for items.

Moreover, some studies look at how technological innovation can be used to forecast demand. On the one hand, a regression and machine learning model was created to offer personalization to shoppers [10]. The designed AI systems use a mixture of discourse exploration and code-based reconstruction of key features from shopping lists. On the other hand, a model for accurately predicting the demand distribution was proposed with linear regression methods [11]. These researchers achieve cost minimization by attending to the behaviour of the digital consumers.

The development of AI systems to solve the challenges in e-grocery has been particularly oriented to manage customer demand and online order delivery. However, the number of publications looking at technological innovation is limited. Therefore, this study has a twofold motivation: (i) identify the most prevalent techniques of AI that are applied in e-commerce and (ii) introduce the potential AI techniques that can be employed in the digital transformation of grocery sales. To carry out this study, the following research question was defined:

RQ: What is the current state of research on the development of AI techniques in e-commerce and which of those techniques can be adapted to e-grocery?

2 Contribution to Applied Artificial Intelligence Systems

The term e-grocery refers to the online sale of food products. Paying special attention to the online channel, this study has focused on discovering techniques to improve the digital transformation. In this context, digital transformation is the integration of technology into business, fundamentally improving how to offer value to customers. This value is of great importance as the boundaries between traditional and electronic commerce disappear [12].

Grocery retailers must allocate a significant portion of revenue to investing in digital transformation. Until now, technological innovation in this sector has only been carried out with simple algorithms [7,8,9,10,11]. Mathematical models have also been understood as AI techniques that allow automated planning [13].

Implementation could increase if AI techniques employed in other sectors were analysed. Therefore, the main objective of this research is to discover AI applications in e-commerce for promoting technological advancements, which will allow grocery sellers to achieve greater flexibility to adapt to the online channel.

The systematic literature review carried out in this article presents AI tools such as machine learning, neural networks and recommendation systems. These publications offer general frameworks, systems, algorithms and methods that are easily applicable to other sectors. If these e-commerce tools were applied in e-grocery, AI techniques would help grocery sellers to improve forecasting and decision-making, customer acquisition and organizational productivity.

In this way, the proposed study is a major contribution as it shows that there are few developed techniques for innovation in the supply chain of e-grocers, which makes this line of research of great future interest for researchers and companies.

From this analysis, we identify potential gaps and opportunities for research and practical improvement and devise guidelines for futures studies.

3 A Systematic Literature Review

The literature review constitutes the main part of the research process [14] because the purpose of this study is to analyse the research carried out on e-commerce taking into account the relationship between technological innovation and applied AI systems. It seems that there are several tools used to manage the supply chain, but none from the point of view of e-commerce [15]. In order to fulfil the proposed objective of this study, the content must follow a clear and decided process structure [16], for which a four-step review methodology is developed [17]. The following four subsections provide the details of each of the four steps.

3.1 Material Collection

The scope of the study begins with selection of the SCOPUS and Web of Science databases. The main search criteria were narrowed according to the keywords of the research question 'artificial intelligence' and 'e-commerce' in the search fields: article title, abstract and keywords. Additional sets of selection criteria stipulate the following: the article is written in English and the document type is an article. The search period is adjusted to the last ten years, ranging from 2011 to 2020. Finally, the search was adapted to the subject areas such as computer science, engineering, decision sciences and mathematics. The search criteria used were adapted to each specific database to guarantee the robustness of the search. The search was carried out in January 2021. The selection process of the publications considered in this study can be summarised as follows. From the first search in the both selected databases, a total of 137 references were identified. After eliminating duplicates, 126 articles remained. Once the set of articles has been selected, we applied a second set of criteria to exclude irrelevant articles. Each author of this paper read every article to ensure that it had the required quality. We defined a customized article inclusion protocol to review titles, keywords and abstracts [18]. The analysis of articles was compared by the authors, discussing criteria and results [19]. Application of these criteria reduced the number of selected publications for analysis and synthesis to 43.

3.2 Descriptive Analysis

In this phase, the 43 selected articles were analysed. The characteristics evaluated were: journal and year of publication. The journal 'Sustainability' stands out from the other publications as it appears 5 times. It is followed by the sources: 'Electronic Markets', 'International Journal of Engineering Education' and 'Journal of Innovative Technology and Exploring Engineering'. By analysing the publication years, information is obtained on the evolution of research works carried out during the last 10 years. It is noteworthy that over 77% of the papers were published between 2019

and 2020. None of the other years represents more than 8% on its own, as shown in Figure 1. The consequence of the distribution in time may be the result of a lack of practical application of the value contributed by these AI tools until 2019.

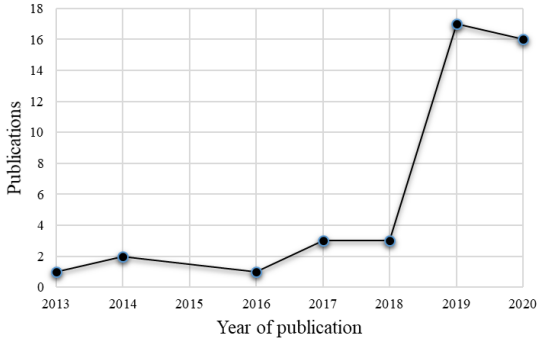

Fig. 1. Classification of articles according to the time distribution

3.3 Category Selection

In order to examine the 43 publications, we broke them down into fundamental parts on the basis of a specific set of characteristics feeding back to our research question. These features were: 'AI techniques' and 'Outcome'. To develop the analysis, we first determined the scientific sources that report a comprehensive list of AI techniques in practice and scientific literature [20,21]. We analyse the AI techniques that the publications focused on according to: AI neural networks, Fuzzy logic, Agent-based systems, Genetic algorithm, Data mining, Support vector machines, Decision support systems, Machine Learning, Expert systems, Bayesian networks, Recommendation system, DVA and Chatbot, AI algorithms or General forms of AI. This last group includes those publications where more than three techniques are discussed. They are usually conceptual publications where the most applied AI tools are determined and where comparisons are made between them. Regarding the outcome, the publications have been classified according to how they develop the topic: approach, system, framework, method, literature review, application or algorithm.

3.4 Material Evaluation

In this stage, the analysed articles were validated according to the approaches selected through a deductive and inductive process. The evaluation ensured that the studies were appropriate and that they had sufficient information to be able to apply the parameters considered for the classification. The analysis helped the organization, categorization, structure, and the main findings of the review to be examined.

4 Research Contribution and Innovation

This section shows the results of the review carried out. Moreover, the studies were analysed in relation to the technique or outcome they were aimed at. Table 1 details the results obtained from the categorization of the reviewed articles.

Table 1. Summary of the categorization of the literature

AI Technique	Amount	Studies
Machine Learning	11	[22, 31, 32, 35, 40, 45, 48, 52, 54, 55, 63]
AI neural networks	7	[32, 38, 44, 53, 54, 55, 62]
Recommendation system	7	[23, 30, 31, 40, 44, 47, 64]
General forms of AI	6	[24, 27, 34, 39, 41, 42]
Support vector machines	6	[44, 45, 48, 53, 54, 63]
DVA and Chatbot	6	[30, 33, 49, 53, 58, 61]
AI algorithms	6	[26, 28, 29, 48, 57, 59]
Data mining	5	[37, 52, 62, 63, 64]
Genetic algorithm	4	[25, 45, 60, 62]
Decision support systems	4	[37, 38, 46, 56]
Fuzzy logic	3	[25, 37, 62]
Agent-based/multi-agent systems	3	[36, 43, 51]
Expert systems	1	[50]
Bayesian networks	1	[38]

As outlined above, this summary shows the frequency of AI techniques. Since some research employs more than one technique, the total frequency of some methods is greater than the number of publications. To be precise, 19 publications (44%) use a single-technique approach, 10 articles (23%) develop a double-technique, 8 (19%) have a multi-technique, and 6 (only 14%) present a more global view on AI systems. The most used technique is machine learning (over 16%). The second-most-frequent techniques were AI neural networks and recommendation systems (10% times).

Another aspect on which the literature in this review is based is the outcome of the study. In this categorization, for each publication we define a unique outcome (an algorithm, a system, a framework, a method, a model, a literature review, an application or an approach). Figure 2 presents the outcomes with an experimental/practical orientation.

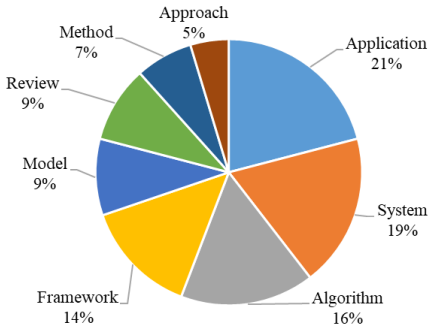

Fig. 2. Distribution of publications by outcomes

5 Conclusions and Future Work

E-commerce increasingly fosters competitiveness and there is a constant need for the application of new methods and technologies [36]. AI techniques are presented as a great opportunity, but they should be approached in the right way since only a third of the projects are successful [35]. Although some research provided insights into the application of AI techniques in e-grocery, there are still many scientific gaps.

The main opportunity for research identified in this study is the need to conduct studies on the implementation of AI techniques in real-world practice. The state of the art could be characterized by lot of theoretical and not so much applied research. Future investigations should include such practical application in companies and with real data, showing quantitative results.

Our research highlights that the most employed AI techniques in e-commerce are e-learning, neural networks and recommendation systems. These publications present systems and algorithms, but there is a lack of methods and approaches for AI systems. In this sense, an interesting future line of research is presented: researchers should focus on developing AI applied systems to find out how technological innovation improves the supply chain management.

Moreover, this literature review highlights many studies focused on consumer behaviour, on how to improve the level of service through either chatbots, algorithms or data mining [33, 39, 52, 63]. Systems of this type allow a relationship to be built between the elements and for each user to make the most appropriate decision. The value contributed in these investigations is very broad, but they do not analyse how these tools facilitate supply chain management. This approach is presented as an interesting line of research to develop in future studies.

Finally, a research gap has been identified in the application of AI techniques in e-grocery. Some tools analysed in this study developed for e-commerce are not so easily adaptable to e-grocers. This case is applicable to algorithms, frameworks and applications focused on logistics, which must be adapted to solve the logistical complications of grocery sellers such as fresh product conservation and tight order delivery times. Publications could focus on implementing ant colony algorithms to improve the distribution of fresh products. This aspect was not taken into account in the publication dealing with colony algorithms in e-commerce [26] and with digital voice assistants [58, 61]. Those authors have not taken into account the implications of using this technique in the management of foodstuff supply chains. This offers a guideline for future studies where the technological innovation will lead to more accurate forecasting and decision-making. As a result, it will be possible to improve customer acquisition and the organizational productivity of e-grocers.

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