Linking green supply chain management practices with competitiveness during covid 19: The role of big data analytics

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ABSTRACT

Although the global green supply chain management (GSCM) practice has attracted considerable scholarly attention, its efficacy for environmental management systems (EMS) and market competitiveness during Covid-19 has not been fully capitalized. Therefore, the existing literature indicates that the important link between GSCM, EMS, and market competitiveness is missing as supply management is crucial to maintaining market competitiveness. To fill this research gap, the current study examines whether EMS affects the relationship between GSCM practices and market competitiveness. We also propose the moderating role of big data analytics and artificial intelligence (BDA-AI) and environmental visibility on these associations from a Covid-19 perspective. We tested a proposed model using the primary data ($N = 283$) from regression-based structural equation modeling (SEM). The results provide empirical support for the impact of GSCM on ESM and market competitiveness. Furthermore, the results show that BDA-AI and environmental visibility strengthen the positive relationship between GSCM-EMS and EMS and market competitiveness, respectively. Current research provides thoughtful insights for supply chain practitioners, policymakers, managers, and academics that organizations should opt for formal EMS, BDA-AI, and environmental visibility to achieve market competitiveness, even in times of crisis such as Covid-19.

1. Introduction

International organizations may seek to gain a competitive advantage through sustainable development, such as introducing innovation in production, improving environmental protection procedures to comply with international regulations (e.g., ISO-14001 certification 2020), increasing green marketing, agile systems, eco-friendly environmental policies to address customers' concerns to environmental issues, and minimizing the environmental impact of production and service activities [1]. The waves of megatrends such as globalization, digital technologies, environmental sustainability issues, stakeholder relations are pushing organizations into an era of uncertainty rather than competition [2]. However, the organizational environment may become volatile, especially during an unpredictable event such as Covid-19, which was declared a pandemic in March 2020 and sparked uncertainty and panic across the globe [3]. Small and medium enterprises (SMEs) are struggling with survival plans during the disruptive events of Covid-19, which require close attention to the integration and coordination of their supply chain management (SCM) to manage customer and supplier demand [1,4]. As a result, the rapid and exceptional Covid-19 outbreak severely disrupted organizational SCM, leaving businesses extremely unstable and facing huge losses in a short time [5,6]. Additionally, environmental awareness is rapidly growing with the proliferation of information and communication technology (ICT) and social media, another challenge that organizations face in a competitive business environment [7].

To estimate the almost unfathomable impact of the COVID-19 pandemic on business, we must first consider that the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak was largely confined to one country (i.e. China), causing global economic damage of $3 billion to $100 billion [8]. In contrast, COVID-19, the so-called "once-in-a-hundred-year pathogen" has swept the world, and its impact on the global economy is expected to be larger and longer-lasting [9]. Concerns emerging during this period have hurt market returns, causing the global financial markets have been thrown into complete disarray [1]. The rising number of positive cases of COVID-19 has further exacerbated

volatility and is fueled by the rapid spread of pandemic-related news and the resulting economic uncertainty across the digitally connected world [10]. Thus, the combination of these factors has drawn unprecedented attention from the organization's SCM in the international community during the pandemic [11].

Despite this unpredictability, organizations may not stay away from the market because they still need different supply chains and services to effectively use their investable surplus [12]. In addition, we believe that an easy transition to a greener and sustainable environment may also retain and attract more customers and investors to invest in businesses, especially when they are confined to their homes during the COVID-19 lockdown and have sufficient free time [13]. SCM supported by ICT and Big data provide sustenance to the organizations through an online interface [14], making SCM easy access possible. However, as seen during the COVID-19 pandemic, in such a volatile market, organizational SCM can be risky and leave stakeholders vulnerable to higher losses. Therefore, the decision not to offer goods and services seems to be a safer and more attractive option than sending goods in a blocked area [15]. Based on the discussion, we believe that there may be a need to protect organizations from their own bad decisions when faced with anomalous events that even the most informed businesses cannot comprehend. Therefore, we believe there is an urgent need to understand the SCM factors that affect organizational competitiveness during the COVID-19 pandemic.

We believe that the pandemic has presented us with a unique opportunity to gain insights from green supply chain management (GSCM) in the face of external pressures. These insights can then help develop policies to protect organizations and better educate them about the risks involved in making environmental decisions during unexpected events such as Covid-19. To our knowledge, previous studies have paid little attention to the impact of GSCM and its outcomes during the Covid-19 crisis. Therefore, it is imperative to study the results of GSCM. Recently, GSCM has gained significant scholarly attention in addressing environmental issues and enhancing organizational sustainability for competitive advantage [16]. GSCM is a more sustainable supply process with added integration and coordination in the business process with a wasteful supply chain, which thereby lowers the overall total cost of business and enhances customer satisfaction [13,16]. Specifically, GSCM is defined as "supply chain capability refers to the ability of an organization to identify, use, and assimilate both internal and external resources and information to facilitate the overall supply chain activities" [17,18]. Organizations are increasingly adopting the GSCM to demonstrate their sincere commitment and sustainability to their stakeholders [19,20]. In addition, scholars have revealed that GCSM is an important determinant to achieve a competitive edge over others [16]. For example, Aćimović et al. [21] have confirmed that GSMC enhances the firms' competitiveness via reverse logistics. Cosimato and Troisi [22] revealed that GSMC helps the organization to balance their economic and environmental performance in globalized competitive business environments. Recently, Chang et al. [23] concluded that employees including managers' ability to seek knowledge and generate ideas will enhance GSCM which thereby promotes competitiveness in the market.

Despite the rapid development of scholarly research on GSCM and its outcomes (e.g., waste reduction, environmental credibility, and pollution reduction), a literature review suggests that research related to GSCM is still at the conceptual level, while the novel role that GSCM practices can play in dynamically evolving organization competitiveness during Covid-19 is still unclear [16,19]. For instance, how GSCM impacts organizational competitive advantages has remained neglected so far. GSCM is not enough to satisfy the environmental concern of the stakeholders. A review of the previous literature has suggested various research gaps and limitations (e.g., Ref. [24]. First, based on this discussion, we contend that rather than focusing only on GSCM features and their association with organizational performance, there is a need to better understand the underlying mechanism of GSCM and market

competitiveness such as Environmental Management System (EMS). EMS refers to "an integrated system and database that enable organizations to share information and resource with internal as well external stakeholders of the firm to comply [25] standard" [26,27]. We responded to the call for research which suggested exploring how GSCM helps the organization to compete in the market [28,29]. Scholars have argued that the adoption of EMS is more likely to expand the organizational benefits such as an increase in investment, attracting good human capital, enhancing quality management, improving the working condition, attracting new customers and suppliers, and reducing pollution [30]. We agreed that EMS not only offers financial benefits but also allows firms to enhance work competitiveness, making it important to explore how GSCM can help the organization to be competitive via implementing EMS in the workplace during uncertain periods like Covid-19. However, in organizational proactive strategies, the underlying mechanism of EMS between GSCM and market competition has rarely been investigated. We believed that understanding EMS' mediating mechanism can enhance the understanding of organizations' better managing the competitive advantage during the uncertain period of times such as Covid-19.

Second, the prior literature has acknowledged that the widespread use of ICT, big data has gained strategic importance in the organization in making sustainable policies [14]. Big Data refers include great variety, huge and increasing exponentially day-to-day basis by volume, variety, velocity, and veracity [31]. Such accumulation of data enables the organization to develop Big Data Analytics and Artificial Intelligence (BDA-AI), which help in transforming data into useful information, thereby useful in decision making and perhaps supporting the supply chain [32,33]. Therefore, guided by the previous research link between BDA-AI and supply chain and future research call to explore the role of BDA-AI in GSCM, we explored the moderating role of BDA-AI between GSCM and EMS [34–36]; Nusrat et al., 2021). It is imperative to investigate the BDA-AI role because GSCM is likely to be well managed when the organization has BDA-AI which thereby facilitates the EMS in the organization. Furthermore, we did not find any study which examined the moderating role of BDA-AI on the association of GSCM and EMS. Thus, to address this gap, the current study helps to uncover how BDA-AI can influence the GSCM practices and corresponding outcomes such as market competitiveness, specifically during Covid-19.

Third, extant literature has primarily focused on moderating roles of intellectual capital [37], lockdown during Covid-19 [38], and green digital learning [39]. To the best of our knowledge, none have explored the role of environmental visibility on the association of EMS and market competitiveness. Environmental Visibility (EV) is defined as the extent to which the organizations disclose their environmental policies and practices to their stakeholders such as environmental pollution and natural resource utilizations [40,41]. In recent accounting studies, environmental visibility has received great scholarly attention [42–44], however, in supply chain literature this concept is new. We believe that EV is a growing phenomenon because of the increased demand for environmental performance information required by the stakeholders, thus contributing to the debate about the effectiveness of EV practices in GSCM, we examined the moderating role of EV at the second stage of our model (see Fig. 1). The rationale behind examining the EV at the second stage, we believe that EMS will be more successful when the organization discloses its actual practices to the stakeholders. There is also a shred of empirical evidence which support this logic that EMS will be more successful when stakeholder have trust in organizational practices and there is no discrepancy between actually disclosed information [45]. Therefore, the current study will provide empirical evidence about the effectiveness of EV in the presence of GSCM and EMS, thereby enhancing the market competitiveness during Covid-19.

In sum, we identify the following visible gaps in the GSCM literature: (a) The research on underlying mechanism between GSCM practices and market competitiveness is limited in width as well as depth, and (b) The focus of prior studies has been on the aggregate impact GSCM practices
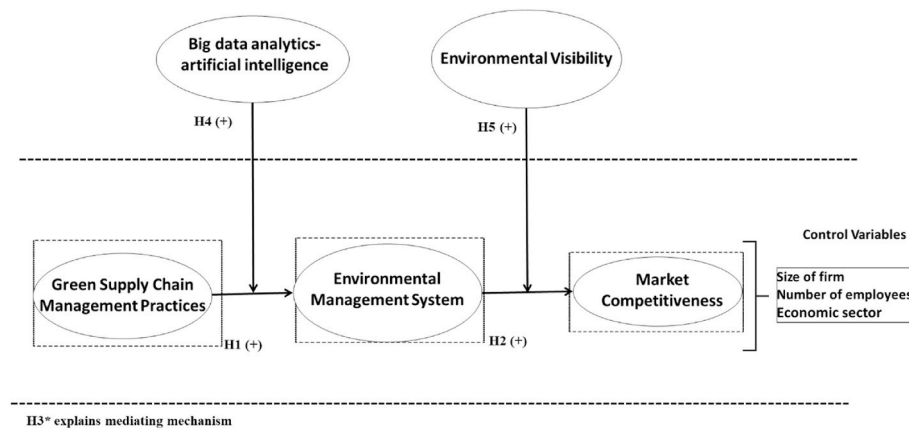
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Fig. 1. Proposed research model.

and the related outcomes in an organization, thereby offering less-nuanced insights. These gaps represent a deficiency in accumulated learnings during uncertain times, which limits the present understanding of the impact of GSCM practices on organizations and their performance, especially during a pandemic situation such as Covid-19. Given the inevitability of greater diffusion of GSCM practices across the world, we contend that there is a need to go beyond aggregate impact GSCM practices on organization performance to consider how GSCM practices associated with the EMS that drive critical contemporary performance parameters such as market competitiveness along with boundary condition of BDA-AI and EV respectively. Taking cognizance of the gaps and the need to bridge the same, we propose to address two research questions: **RQ1:** How do GSCM practices influence the EMS and thereby market competitiveness during Covid-19? and **RQ2:** What are the roles of BDA-AI and EV on the association of GSCM and market competitiveness at the first and second stage respectively during Covid-19?

Three new contributions of this study can be summarized as follows: First, it extends the understanding of limited and somewhat skewed findings of prior GSCM focused studies by considering the outcome such as pollution reduction and supply efficiency. The current study provides a novel mechanism of EMS to increase the market competitiveness by adopting GSCM practices specifically during Covid-19. Second, it extends the understating of using BDA-AI to enhance the EMS during Covid-19 situations and thereby competitive advantages. Herein, the current study provides insights into how an organization can enhance the effectiveness of GSCM with the integration of BDA-AI. Finally, the study advances the understanding of EV in EMS and GSCM context. Since GSCM addressing environmental issues and EMS provides an integrated database for use of information, EV explicating the association of EMS with market competitiveness is quite useful during an uncertain situation like Covid-19.

2. Literature, theoretical perspective, and hypotheses development

2.1. Green supply chain management (GSCM)

GSCM has received attention in the supply chain and natural environment in the extant literature [1,2,6]. GSCM needs well-integrated and coordinated efforts among business processes such as purchasing, manufacturing, marketing, and logistics (e.g., see Ref. [24]. GSCM required a business strategy aligned with the supply chain process to satisfy end customers as well as other stakeholders [11]. Generally, companies' motive to adopt green business practices (GBP) is likely to reduce pollution, reduce waste and energy use, use renewable materials, and incorporate and implement resource shelter actions to ensure that products/services are provided in an environmentally sustainable

manner [46]. For example, literature provides three key approaches of GSCM 1) reactive "companies commit minimal resources to environmental management, label products that are recyclable and use "end of pipe" initiatives to lower their environmental products" 2) proactive "companies start to pre-empt new environmental laws by realizing a modest resources commitment to initiate the recycling of products and designing green products" and finally 3) value seeking in which "companies integrate environmental activities such as green purchasing and ISO implementation as strategic initiatives into their business strategy" [47].

Nevertheless, extant literature has discussed various outcomes of adopting GSMC practices, however, the existing arguments regarding GSCM and market competitiveness are insufficient and controversial. For example, GSCM literature presented inconsistent findings regarding the effectiveness of GSCM in the organization. Scholars did not have a consensus on whether GSCM practices foster profitability or not. Extant studies provide theoretical arguments in support and opposing both arguments. For example, on one side, scholars argue that it is perhaps a burden on an organization to achieve a competitive advantage [48]. [49] showed serious concerns about losing competitive advantage as GSCM practices increase the overall cost of the business. Another study revealed that GSCM practices are more likely to enhance operation efficiency rather than profitability [50]. [51] failed to establish a strong connection between GSCM and the profitability of the firms.

Whereas on the other side, scholars argued in favor of GSCM adoption and they established based on theoretical reasoning that GSCM adoption enhances the financial performance of the organization. For example, Freeman [52] identified based on stakeholder theory that organizations produce externalities that affect both parties (stakeholders) internally as good externals. Externalities exert pressure on the organization to adopt environmental-friendly policies and reduce the wastage of resources. Stakeholder theory argued that taking care of stakeholders' expectations will enhance the organizational performance and thereby increase the profitability of the firms [52,53]. Moreover, it has been determined that organizations perhaps achieve a competitive advantage if they adopt eco-friendly practices and the best stakeholder support [54]. Few scholarly claimed that GSCM has an indirect effect on the profitability of the firms. For instance, Feng et al. [55] established that GSCM has no a direct influence on the profitability of the organizations since it mainly emphasizes operating process and resource management which may not directly enhance the financial performance. In the next section, we focused on the ongoing debate of GSCM and Covid-19.

2.2. GSCM and Covid-19

After the Covid-19 outbreak, the effectiveness of GSCM has become more controversial. Both in favor and against of GSCM arguments have

drawn scholarly attention. For example, scholars have argued that GSCM adoption will never protect the organization from Covid-19 shocks. They based their augment on several reasons. Based on prior experience, for example, King & Lenox [51] and Laari et al. [50] suggested that GSCM has no relationship with the financial performance of the organization nor does it get preferential support from investors during an uncertain time. Therefore, the criticizer took this opportunity and suggested that GSCM will not be effective during Covid-19.

Next, it is remarked that investment in the supply chain may be curtailed due to new challenges such as those imposed by Covid-19. For example, in a recent study, Amankwah-Amoah [56]; despite organizations are opting new environmental policies, they are often abandoned when faced with new and unpredictable challenges. Organizations barely maintain the momentum when financial resources are severely strained (for instance due to Covid-19) and it will be a great challenge to maintain momentum for investing in eco-friendly sustainable practices. Furthermore, the ineffectiveness of GSCM is based on the fact that COVID-19 is not an environmental crisis, but a social and health crisis. This may significantly change the company's priorities, from environmental sustainability to social sustainability. For example, as per the "Global Risk Report 2020″ of the World [57]; global participants did not mention the risk of infectious diseases in the top five risks. Investors may think that this may change after COVID-19 because social and health issues become more important than environmental aspects.

On the other side, it has been argued that GSCM perhaps protects the firms against crises such as Covid-19. According to Stakeholder theory, organizations commit to their stakeholders toward the environment and are likely to receive more return when engaging in CSR practices, especially during the time of crisis. However, the finding showed return is slow but sustainable [12,58]; Khalid et al., 2021). It is suggested that the organizations invested in GSCM are more agile in coping with an uncertain situation like Covid-19 because they are capable of quickly managing their supply chain and avoiding losses due to a shortage of raw material [6]. In recent studies, GSCM has been endorsed as a viable component of sustainability that helps the stakeholders and organizations in the long run and is attentive to sudden environmental changes [13,59]. Furthermore, according to Balan and Conlon [34]; GSCM enables an organization to get penetrate the market, increase their reputations and make them more competitive. Therefore, scholars have emphasized that the research on GSCM, especially during time of crisis like Covid-19, should be inclusive both in width and depth and need further exploration to enhance the market share and competitiveness. Therefore, in this study, we extend understanding regarding GSCM practice and underlying mechanisms such as EMS which thereby increases market competitiveness (See Fig. 1).

2.3. GSCM, EMS and market competitiveness

The developers of ISO 14001 have recognized the key role that EMS plays in any company's efforts to achieve the goal of improving the environment and corporate performance [60]. EMS focus may even indicate that EMS is so important for the organization that no one can gain a competitive advantage unless it has an effective EMS that meets the ISO 14001 standards. For example, extant literature discussed that EMS 1) is an environmental policy committed to preventing pollution, 2) facilitates the organization in planning, controlling, and monitoring policies for the betterment of the businesses, 3) improves management and employee commitment toward eco-friendly environment 4), provides resources for personnel development such as training on a day-to-day basis and 5) encourages the investor and other stakeholders to maintain EMS within their organizations. EMS is a well-recognized tool developed by the European Commission (EC) which perhaps facilitates the shift toward a more circular economy [61].

The EMS involves formal systems and databases which provide an integrated system for personnel training, monitoring, summarization, and reporting of professional environmental performance information

to the company and stakeholders [62]. EMS is mainly based on an internal formal structure with a prime motive to save resources, control pollution, and wastages trained and timely reporting to the top management for strategy development. Such formal information is usually shared in the annual report of companies for image building [63]. Based on the aforementioned definitions, our focus is to examine the relationship between such systems, the environmental choices the company involves such as GSCM thereby market competitiveness. Market Competitiveness is referred to as "the market where numerous competitors compete for each other, however factor that allows a company to produce goods or services better or cheap than the rest such as eco-friendly products, higher sale turnover, higher share in market and export." [64,65]. It helps them gain more margin as compared to rivals of the company [38]. EMS is a process, not a performance measure that varies from organization to organization. However, EMS's main purpose is to facilitate the organization to achieve the desired environmental objective. Underlying this approach, both GSCM (discussed earlier) and EMS are practical. Both organizational capabilities to manage both GSCM and EMS together will influence positively overall SCM and enhance the performance [66]. For example, it has been noted that GSCM adopters are more likely to practice EMS formally which has a synergy effect on organizational performance [67]. However, they did not find such relations in crisis periods like Covid-19 and did not test the formal EMS relations with GSCM.

In a recent study [7], draw attention towards new features such as employee expressive and instrumental relationship, sharing of knowledge, and commitment within organizations embedded in EMS which perhaps more likely enhance the market competitiveness. GSCM and effective EMS systems better equip the managements to better manage their resources and operations. EMS system will help the organization to deploy GSCM practices in a better way. For example, EMS may facilitate the organizations manage the organizational change and developments during the implementation of GSCM practices [2], thereby leading to increased financial stability [6]. Furthermore, the EMS system can enable the organization to use cross-function resources and information within the organization that perhaps help them to manage environmental issues [61]. For example [62], has suggested that EMS adoption conserves resources which perhaps leads to firms' financial stability in small and medium enterprises (SMEs) [67]. pointed out that complete EMS is the only way to enhance organizational performance.

Extant literature has discussed various determinants of market competitiveness. For example, organizational reputation is a key factor that could enhance the organizational market competitiveness [65]. Adopting eco-friendly practices, eco-innovation (e.g., new environment-friendly products), EMS certification (e.g., ISO 14001) will enhance the external reputation of the firm [3,10,68], thereby leads to increase in market competitiveness and increase the profitability [59, 67]. Based on the above discussion and suggestions, we argued that GSCM will be more effective if it is aligned with a formal EMS system, which not only helps the organization to manage the scarce resource but also enhance the market competitiveness and increase the financial stability, especially during Covid-19. Hence, we hypothesize the following:

H1. GSCM Practices is positively related to EMS within the organization

H2. EMS will enhance the market competitiveness

H3. EMS mediate the relationship between GSCM practices and market competitiveness

2.4. Big data analytics-artificial intelligence (BDA-AI)

Big data has referred to as large or complex data sets that usually exceed exabytes. It goes beyond traditional systems with limited capabilities in storage, processing, monitoring, deciphering, and

visualization [67]. On a day-to-day basis, data is increasing which perhaps soon reached to zettabyte per year [69]. In today's highly competitive market, the IT revolution, customer awareness, and globalization are forcing organizations to change. Competition among organizations is replaced with competition between organizations and supply chain practices. Therefore, supply chain professionals are working hard to manage the massive data to achieve an integrated, efficient, effective, and agile supply chain system [39]. The explosive growth of data volume and different types of data in the entire supply chain has spawned the need to develop technologies that can analyze large amounts of data intelligently and quickly. BDA-AI has been endorsed as a best practice, which enabled the organization to draw useful information from the huge amount of data and use this information to manage the supply chain problems [14,39].

Recently, scholars have recognized the role of BDA-AI in GSCM [14, 70]. Due to the increasing environmental awareness of global warming, toxic pollutants, and chemical spills, GSCM has become an important issue of concern for managers, policymakers, and the public [69,71]. To promote GSCM, both emerging markets, i.e., India and China, adopt digital technologies such as smart detection devices to control the environmental issues within and between companies. For instance, in Jiangsu Province of China, a smart device was used to collect real-time environmental data which produce millions of flow and different streams in an unstructured manner [32]. In such cases, BDA-AI will be helpful to process the unstructured data to reveal thoughtful insight. For instance, BDA-AI can analyze dynamic energy consumption and carbon emission data in real-time, and support the optimization of the manufacturing process with the goal of energy-saving and emission reduction [35,72].

There is anecdotal evidence that few organizations utilized BDA-AI for GSCM practices. For instance, "Beijing Tiantan Biological Products Company" revealed in its 2016 CSR Report that, "Real-time monitoring is carried out via big data and other techniques to strengthen energy consumption control." Using BDA-AI, firms generate useful information to improve environmental practices [31]. Moreover, BDA-AI practices have enabled the organization to reduce carbon emission, reduce the wastages of natural resources, and utilization of green product innovations [39,73]. Therefore, we believe that BDA-AI may be a useful technique to better deploy GSCM practices and improve the effectiveness of EMS within an organization. Hence, we propose the following assumptions:

H4. : During Covid-19, BDA-AI moderates the relationship between GSCM practices and EMS in such a way that the relationship is stronger when BDA-AI usage is higher (vs. lower).

2.5. Environmental visibility (EV)

Stakeholders' access to environmental information has been acknowledged which has an impact on corporate activities and stakeholders' expectations [43]. The revelation of environmental information to stakeholders is perhaps a basic element to start a dialogue, aiming to consider the needs of stakeholders and make corresponding decisions [42]. In addition, from the perspective of stakeholders, the response to the many supporters interested in the company's performance entails various contours [74]. As a result, organizations are making environmental information more visible by issues such as "triple bottom line", "sustainability" and "CSR" reports [40]. To become visible and transparent, these reports target different stakeholders, such as shareholders, governments, NGOs, unions, customers, and other stakeholders [5]. More broadly, the extant literature shows that EV will benefit the organization from greater stakeholder inclusiveness [42,75].

Disclosure of environmental information includes feedback from stakeholders, which will help improve internal environmental policies [75] and thereby market competitiveness [65]. Many studies have shown that environmental revelation can affect profitability by improving a company's reputation, and if stakeholder-specific issues are addressed, a broader impact can be achieved [43]. EV should represent the same information as the organization implemented to address sustainability issues. If the actual policy differs from the disclosed policy, it may undermine the disclosure relationship trust [76,77]. For example, scholars have debunked concerns that organizations may have difficulty implementing these visible policies in their organizations [78] because stakeholders can easily identify mismatches between actual and disclosed information such as green practices and EMS [79]. Therefore, this relationship distrust may be ruled by establishing a formal EMS and the organization's reputation, then EV may be more likely to increase the company's competitiveness in the market.

In organizations, EVs contribute to environmental sustainability even more than other business processes such as production and distribution [43,76]. Companies that use EV practices to share transparent information about environmental performance in their supply chains may attain better results. For example, the transparency in disclosing means revelation of information to their stakeholders and evaluating and managing their operations and supply chain activities to implement EMS practices. Therefore, consistent with the transparent strategy proposed by Marshall et al. [45]; we proposed that EV will likely strengthen the relationship between EMS and market competitiveness.

H5. During Covid-19, EV moderates the relationship between EMS and market competitiveness in such a way that the relationship is stronger when EV is higher (vs. lower).

3. Methodology

The current study aims to test the EMS mechanism through which GSCM practices impact firm competitiveness. Further, we examined the moderating role of BDA-AI and EV at the first and second stages of the proposed model, respectively. To test our proposed model, we collected primary data using a survey from "Italian Nationals". Respondents were recruited from the Food industry using prolific (i.e., a web-based self-service online platform to collect data) who met the inclusion criteria provided in the survey list. The questionnaire was drawn using existing validated measures based on relevant and Covid-19 literature from the field of logistics and GSCM. Before administering the survey items, our questionnaire was pre-tested multiple times by the operation and supply chain manager, academician, and scholars. In the light of their feedback, survey items were modified according to the context of the study. For example, we added a few examples and a glossary of a few items in the survey items to clarify the meaning of BDA-AI and EV. Because the current focus of the study is on environmental suitability and supply chain practices at the organization level, we targeted the operation manager, supply chain manager, logistic manager, and middle-level managers who are responsible for supply during Covid-19 and sustainability of the company. Respondents were assured that their responses were kept confidential and only used for study purposes.

Our target sample includes a list of "Top Italian Food Producers" and the "Italian Food Producers Association". We recruited the food industry only according to the context of the study during Covid-19. The Italian food industry has appeared to be leading turnover of about 4.1 billion euros in the 2018 year [80]. For example, the food companies' responsible behavior towards GSCM and EMS has received increased attention from citizens and other stakeholders [76]. The Italian food industry is the second most important sector of the Italian economy and

Table 1
Respondents profile. %.

Gender	Male	54.8
	Female	45.2
Age	25–30 years	37.2
	31–35 years	36.7
	36–40 years	25.4
Qualification	Graduate	30.4
	Post Graduate	58
	Doctorate	11.7
Experience	Less than 5 Years	12
	5–10 Years	29.7
	11–15 Years	12.7
	16–20 Years	27.6
	Greater than 20 Years	18
No of Employees	Less than 100	75.3
	101–250	24.7
Economic Sector type	Private Sector	51.2
	Public Sector	23.3
	Multinational Corporation	24.5

plays an important role in serving the whole country during the pandemic severe lockdown [81,82]. More, fresh and perishable commodities produced or used face price hikes during the first wave of Covid-19, however, the flexibility of transportation and logistics ensure the stability of prices for the end-users. Total 400 companies were requested to participate in the survey, 330 give their consent to participate, representing an 82.5% response rate. However, only 317 responses were received out of which 34 were discarded due to incomplete information. The final sample was reduced to 283 which we used to test the model. Demographics of the sample are presented in Table 1.

3.1. Measures

3.1.1. GSCM

GSCM were assessed using two dimensions such as internal GSCM and external GSCM practices. Consistent with theoretical perspective, internal and external GSCM responses were recorded with Longoni and Cagliano [40] using 4 and 5 items scales respectively. A sample item was "During Covid-19, to what extent the following practices have been adopted in the manufacturing process by your company in the last one year [waste reduction practice]." whereas for external GSCM sample item was "During Covid-19, to what extent the following practices have been adopted in the manufacturing process by your company in the last one year [Supplier selection based on sustainability competences (e.g., clean technologies, environmental programs)" all items were recorded using 5 points Likert Type scale "not at all (1), a bit (2), quite (3), a lot (4), very much (5)"

3.1.2. EMS

Organizational' EMS was measured using 19 items scale adapted from Ref. [76]. A sample item was "During Covid-19, to what extent a firm is involved in Environmental Management Systems activities to the following stakeholders [EMS procedures are formally documented]? All items were captured using 5 points Likert Type scale "not at all (1), a bit (2), quite (3), a lot (4), very much (5)"

3.1.3. EV

EV has been captured based on respondents' perception of the extent to which organizational' disclosed information regarding their environmental practices. EV has been captured using 12 items scale adapted from Longoni and Cagliano [40]. A sample item was "During Covid-19, to what extent information about environmental information is visible to the following stakeholders [Suppliers]. All items were captured using 5 points Likert Type scale "not at all (1), a bit (2), quite (3), a lot (4), very much (5)"

3.1.4. BDA-AI

BDA-AI was measured using 4 items scale adapted from Benzidia et al. [39]. A sample item was "During Covid-19, to what extent the information about big data analytics-artificial intelligence has been adopted in the organizational integration process. For example, use of advanced analytical techniques (e.g., simulation, optimization, regression) to improve decision-making? All items were captured on a five-point liker type scale "1 = strongly disagree, 2 = disagree, 3 = neither agree not to disagree, 4 = agree and 5 = strongly agree.")

3.1.5. Market competitiveness

Market competitiveness was assessed subjective measure adapted from Daddi et al. [73]. Market competitiveness was captured using 4 items scale. A sample item was "Indicate your level of agreement with the following statements on what kind of Market Competitiveness your organization experiences during Covid-19, for example, easier access to the capital market because of a lower environmental risk (Specify: "1 = strongly disagree, 2 = disagree, 3 = neither agree not to disagree, 4 = agree and 5 = strongly agree."). We presented a complete list of survey items in appendix-A.

3.2. Common method bias (CMB)

As the collected data was self-reported, it perhaps suffers from CMB [83]. To manage the potential threat of CMB various measures. First, to rule out the CMB at the initial stage of data collection, we employed anonymity and reverse coding for a few items; second, we used Harman's Single factor test consistent with the recent study [7,12]. The results showed that a single factor only explained 28.37% of the total variance which is pretty lower than the cut-off limit of 50% (see Table 2).

Table 2
Harman's single factor.

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.05	28.37	28.365	6.34	13.78	13.78
2	5.97	12.97	41.34	5.33	11.58	25.36
3	4.90	10.65	51.98	4.99	10.84	36.20
4	3.02	6.57	58.56	4.82	10.48	46.67
5	2.74	5.95	64.51	3.49	7.58	54.25
6	2.21	4.80	69.31	3.39	7.36	61.61

Table 3
CFA with Marker Variable fit indices.

Model	χ2 (df)	CFI	RMSEA (90% CI)	LR of Δ χ2	Comparison
CFA with Marker	1939.9 (1056)	0.958	.057 (.060-.074)		
Baseline	1895.6 (1070)	0.975	.056 (.078-.088)		
Model-C	1868.408 (788)	0.926	.056 (.018-.045)	27.192, df = 5, p = 0.004	Baseline
Model-U	1850.4 (743)	0.947	.058 (.078-.096)	18.008, df = 44, p = 0.075	Method-C
Model-R	1867.2 (759)	0.934	.059 (.079-.088)	16.8, Df = 29, p = 0.894	Method-U

Note: CFA = confirmatory factor analysis, χ2 = Chi square, df = degree of freedom, CFI= Comparative fit index, RMSEA, Root mean square error of approximation, LR = , Likelihood ratio test, U = unconstrained, C = constrained, R = restricted.

Table 4

Reliabilities and validities.

	x̄	SD	CR	AVE	MSV	ASV	1	2	3	4	5	6
1. BDA-AI	3.39	1.20	0.85	0.59	0.17	0.09	*0.77*					
2. EMS	3.75	0.84	0.96	0.56	0.31	0.19	0.37	*0.75*				
3. EV	3.75	0.87	0.91	0.51	0.25	0.08	0.28	0.50	*0.71*			
4. GSCM (Internal)	3.58	0.94	0.94	0.77	0.31	0.15	0.41	0.56	0.22	*0.88*		
5. MKTC	4.15	1.20	0.94	0.82	0.24	0.11	0.27	0.49	0.14	0.47	*0.90*	
6. GSCM (External)	3.10	1.00	0.86	0.62	0.00	0.00	-.01	0.06	0.09	0.01	-.04	*0.79*

Note: ** Correlation is significant at the 0.01 level (2-tailed). GSCM = Green Supply Chain Management; EMS = Environmental Management System; BDA-AI = Big Data Analytics and artificial intelligence; EV = environmental Visibility, MKTC = Market Competitiveness, CR = composite reliability, AVE, Average variance extracted, MSV = maximum shared variance ASV = average shared variance, x̄, Mean, SD = , Standard deviation.
Bold and Italic diagonal values representing the square root of AVE.

Third, CFA-marker variable technique was used to completely rule out CMB issues from the data (William et al., 2010). CFA-maker is based on five steps i.e., Confirmatory Factor Analysis (CFA) with marker, baseline model, Method-C, Method-U, and finally Method-R. The detailed results of the CFA-marker showed that there is no issue of CMB in the data (see Table 3).

4. Results and findings

We employed a structural equation model (SEM) using AMOS (27 V) to test the proposed model. AMOS enables to test covariance (CB-SEM) and as well variance-based SEM (VB-SEM) and both of these measures were successfully adopted by the scholars to test their hypotheses (e.g., Ref. [7]. We used variance-based SEM i.e., (VB-SEM) to test our model because VB-SEM is more lenient regarding sample size, best suited in testing the theory (Talwar, 2020). We tested model measurement and structural model.

4.1. Measurement model

We tested the measurement model with both reliability and validity using suggested methods and criteria (e.g., Refs. [84,85]. According to those experts, validity should be evaluated through factor loading (confirmatory factor analysis-CFA) and composite reliability (CR) and its outcome values should be greater than the advised cut-off (0.7). Similarly, validity should be evaluated through AVEs and the values should be greater than the advised cut-off (0.5) and greater than the corresponding correlation of the construct respectively. In our case, all CFA values and CR is greater than 0.70 (except two items which we excluded from analysis) which shows there is not an issue of convergent validity (please see appendix-B for details). Moreover, Fornell and Larcker's [84] tool for such validity was applied to understand the values by comparing the interrelationships of latent factors with values of √AVEs. Indices of discriminant validity indicate pretty good validity for the factor and the AVE of all factors is greater than MSV and ASV. Following Table 4 shows that discriminant validity exists as per evaluation methods of the experts [84,85].

We further rule out the validity with HTMT techniques suggested by Henseler et al. [86]. This technique is highly employed by current researchers (e.g., Refs. [7,86]. Therefore, we considered a unique tool on a present instant where experts advocated the values should lower than 0.85 to achieve the desired level of validation [86]. HTMT results show the values as per advised level (i.e., <0.85) as follows in Table 5.

Additionally, the measurement model returned a pretty good model fit indices which we presented in Table 6. It is recommended by scholars to understand the model fit indices before further applying path relationships among latent variables of the study. With such consideration

Table 5

HETEROTRAIT–MONOTRAIT (HTMT).

	1	2	3	4	5
1. BDA-AI					
2. EMS	0.640				
3. EV	0.569	0.295			
4. GSCM (Internal)	0.491	0.180	0.476		
5. MKTC	0.401	0.352	0.421	0.283	
6. GSCM (External)	0.081	0.066	0.015	0.048	0.015

GSCM = Green Supply Chain Management; EMS = Environmental Management System; BDA-AI = Big Data Analytics and artificial intelligence; EV = environmental Visibility, MKTC = Market Competitiveness.

Table 6

Model fitness indices for SEM.

Model Test	CMIN/DF < 5	GFI> .9	AGFI>.9	NFI> .9	CFI> .9	RMSEA <.1
Measurement Model	χ2 (1939.9), df = 1056, χ²/df = 1.83	.947	.949	.941	.958	.057
Hypothesized Model	χ2 (10.758), df = 09, χ²/df = 1.195	.987	.971	.929	.987	.026

χ² = chi-square, DF = degree of freedom, GFI- = goodness of fit index, AGFI = adjusted goodness of fit index, NFI = "normed-fit index" CFI = "Comparative-fit index" RMSEA "root mean square error of approximation".

and using the AMOS tool, the following model fit indices were calculated as evaluated using advised cut-off points (e.g., Refs. [84,85]; Hu & Bentler, 1998; Scott, 1995). Table 6 shows the cut-off values and current model fitness values.

4.2. Structural model

Structural path results are presented in Table 7. First, it was assumed in H1 that GSCM has a positive connection with EM. The hypothesis is supported because of the positive outcomes and path effects such as GSCM →EMS at (β = 0.34***; SE = 0.03; p < 0.0). Likewise, hypotheses were proposed to affirm the analysis about large items construct of EMS and market competitiveness as follows. It was assumed in H2 that EMS has a positive connection with market competitiveness during Covid-19. The hypothesis is supported because of the positive outcomes such as EMS→ Market Competitiveness at (β = 0.53***; SE = 0.01; p < 0.00). It

Table 7
Standardized regression coefficients.

Variables	Environmental Management System			Market Competitiveness		
	B (se)	C. R	p	B (se)	C. R	p
Size of Firm	*NA*	*NA*	*NA*	*-.003 (.15)*		*.67*
Employee Experience	*NA*	*NA*	*NA*	*.02 (.08)*		*.55*
Economic Sector	*NA*	*NA*	*NA*	*.008 (.05)*		*.16*
Green Supply Chain Management	.34 (06)		.00	NA	NA	NA
Environmental Management System	NA	NA	NA	.53 (.07)		.00
Big data analytics and artificial intelligence	.09 (.06)		.00	NA	NA	NA
Environmental Visibility	NA	NA	NA	.22 (.05)		.00
R²	.294			.697		
Indirect effects				B (se)	UCLI-LCLI	
Indirect effect of GSCM on Market Competiveness via EMS				.19 (.01)	.21–.28	
Moderated effects						
Green Supply Chain Management * BDA-AI				.13 (.02)	.10–.19	
Environmental Management System* Environmental Visibility				.48 (.01)	.34–.73	

Note = *Italic* represents control variables, BDA-AI = Big data analytics and artificial intelligence, B = beta, se = , standard error, p = confidence interval, GSCM = , Green Supply Chain Management, EMS = Environmental Management System, NA= Not applicable.

was assumed in H3 that EMS mediate the positive connection between GSCM and market competitiveness. The data supported this hypothesis because of the positive outcomes such as GSCM→EMS^{indirect}→market competitiveness ($\beta = 0.19^{***}$; [Biased–Corrected Confidence Interval 0.21^{LOWER}, 0.28^{UPPER}, SE = 0.01; p < 0.00).

For moderation analysis, we proposed in H4 that BDA-AI moderate the relationship between GSCM and EMS. The hypothesis is supported because of the positive moderation between GSCM and EMS at ($\beta = 0.13^*$; SE = 0.025; p < 0.00) (see Fig. 3 and Table 7). In summarizing lines, the moderating results suggest that a higher level of BDA-AI is associated with an increased level of organizational EMS practices is likely to be higher when organizations have the higher option using BDA-AI. The finding also implies that respondents with a higher degree of using BDA-AI are more likely to engage in EMS. Finally, it was assumed in H5 that EV moderates the relationship between EMS and

market competitiveness. The hypothesis is supported because of the positive moderation between EMS and market competitiveness at ($\beta = 0.48^{***}$; SE = 0.015; p < 0.00) (see Fig. 4 and Table 7).

5. Discussion

The model yields the proposed relationship among GSCM, EM, EV, BDA-AI, and market competitiveness by employing the empirical design from the Italian Food industry during Covid-19. This study promotes the notion of GSCM on how incorporation with GSCM, EM, EV, BDA-AI practices may get market competitiveness during the period of crises such as Covid-19. Organizations can establish a better environment by emphasizing GSCM and BDA-AI adoption that eventually leads to attaining the organizational competitive position. Besides, this study proposed five hypotheses to explore the multidimensional analysis as summarized in Fig. 2.

RQ1 inquired about how GSCM practices can enhance the effectiveness of EMS during Covid-19. To address this question, we tested the direct relationship between GSCM and EMS (i.e., H1). The findings affirmed the significance of GSCM in that it enhances the EMS within
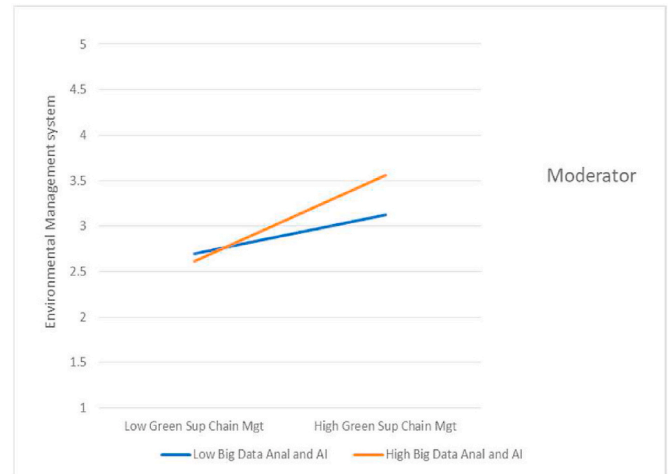

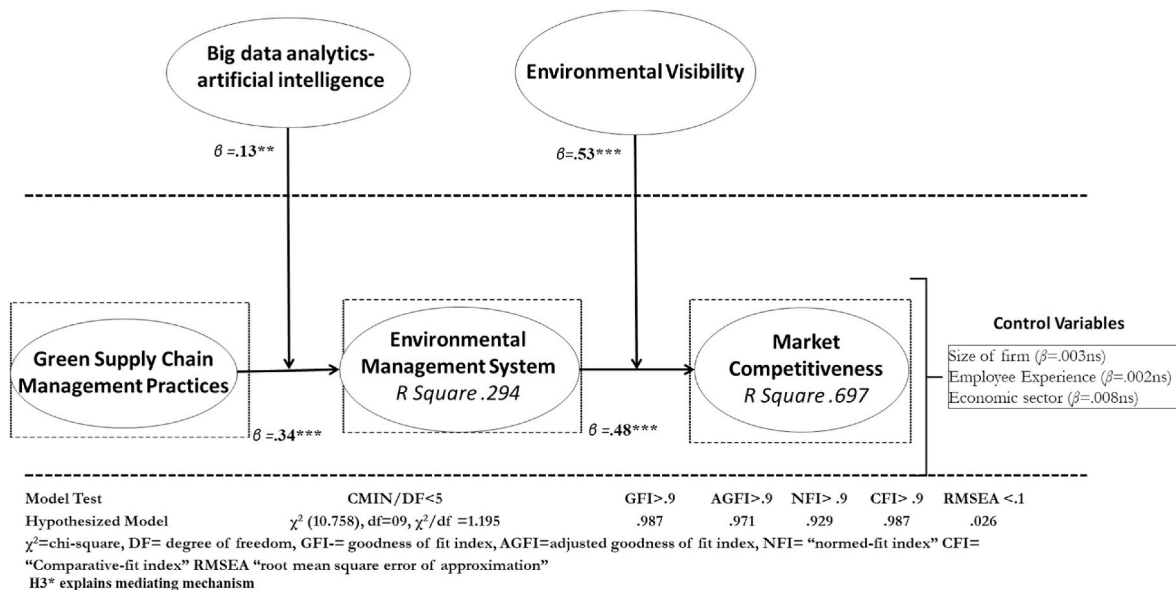**Fig. 3.** Moderating role of Big Data Analytics and Artificial Intelligence.

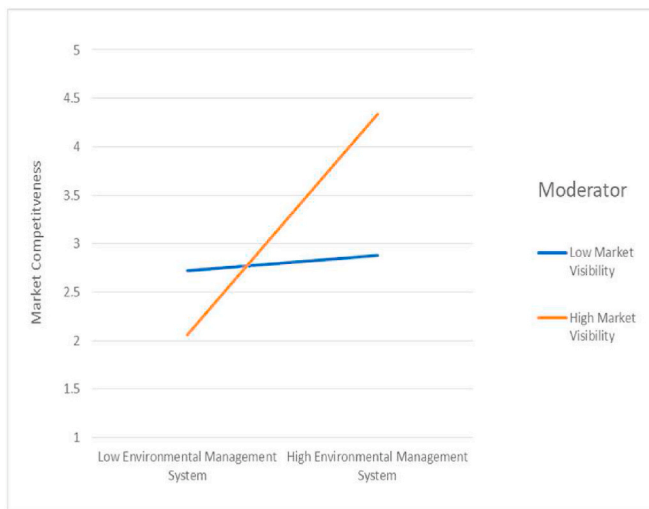**Fig. 2.** Structural model results.

Fig. 4. Moderating role of Environmental Visibility.

organizations (e.g., Refs. [87–92]. This finding is consistent with existing claims which state that ESM is likely to enhance the GSCM effectiveness [26,30]. The second part of the RQ1 proposed the direct relationship between EMS and market competitiveness (i.e., H2). The results affirmed our expected results and confirmed that EMS adoption during Covid-19 will enhance the market competitiveness. These findings are contributed to the ongoing debate regarding the effectiveness of formal EMS systems in the workplace and many scholars have different viewpoints [67]. Our results suggested that during a crisis like Covid-19, the adoption of EMS within the organization will likely help in achieving market competitiveness. In addition, we also tested the mediating effect of EMS (i.e., H3) between GSCM and market competitiveness. We found the supporting mediating effect which implies that implementation of GSCM within the organization will increase the effectiveness of EMS. The result is cognizance with existing studies that EMS will enhance the capability to utilize and implement GSCM effectively which thereby enhances the market competitiveness (e.g., Ref. [27]. This finding is also supported by the stakeholder theory and the extant literature other than the EMS mediation perspective [54]. Furthermore, the finding further suggested that to mitigate the uncertainty among the stakeholder during Covid-19, implementation of GSCM and EMS will support to be competitive in the market. Given the unexpected return due to the unpredictable movement of the organization, investors perhaps trade with the organization because of sustainable and eco-friendly practices.

RQ2 inquired about the moderating roles of BDA-AI and EV (i.e., H4 & H5) on the association of GSCM and market competitiveness at the first and second stage respectively during Covid-19. To address the first part of the question, we examined whether BDA-AI which was captured subjectively enhances or diminishes the strength of association between GSCM and EMS. The evidence fully supported the moderating role of BDA-AI on the relationship between GSCM and EMS. The positive moderating effect of BDA-AI on the relationship between GSCM and EMS implies that when organizations use BDA-AI in their decision making especially during the period of crisis (e.g., Covid-19), the relationship between GSCM and EMS will get stronger. The organization is likely to use GSCM practices and it more likely enhances the effectiveness of EMS, when BDA-AI usage is higher. Our findings to adopt BDA-AI as a moderator are consistent with a few past works where experts utilized BDA-AI as moderator to affirm its connections in distinct themes and dimensions but other than EMS and GSCM (e.g., Refs. [93,94]. The second part of RQ2 stated that EV will strengthen the relationship between EMS and market competitiveness. EMS will further contribute positively towards market competitiveness when organizations reveal a higher level of EV to their stakeholders. This result the plausible

considering the nature of EV, where environmental information is shared openly and transparent to all stakeholders, thereby surprisingly increasing the profitability and creating a competitive advantage for the organization. Our finding is in line with the existing research which stated that transparency will help the organization win the trust of the stakeholders and perhaps increase their financial performance [95].

6. Implications, limitations, and future research call

6.1. Theoretical implications

First, the current study contributes to the mechanism of EMS and its relation to market competitiveness. We addressed the stakeholder concern regarding the adoption of GSCM practices and provide a broader perspective on how GSCM adoption through EMS will increase the market competitiveness. Prior research has inconsistent dialogues regarding the effectiveness of GSCM practices in the organization such as the considerable wastage of resources, increase in business cost, and low profitability [46,56]. However, we provided empirical support and evidence that GSCM adoption will more likely be successful when implemented along with EMS within the organization, thereby it will enhance the market competitiveness.

Second, we found the positively moderating role of BDA-AI on the association between GSCM and EMS. Statistical relationships supported the proposition of various other studies which suggested that BDA-AI usage increases the organizational decision-making capability and stakeholder collaboration [14]. For instance, in the recent study of engineering and technology management, it has been proved that BDA-AI technologies positively impact supplier selection. However, none have explored the BDA-AI role in GSCM and EMS perspective during Covid-19. Furthermore, prior literature considers GSCM implementation as a tangible resource, thus we provided a novel contribution that BDA-AI technology will help in GSCM and EMS integration in the internal process of the Food industry during the Covid-19 situation. More specifically, we suggested that existing of big data in the Food sector is an asset that needs processing in analysis in reducing the uncertainty among the stakeholders during Covid-19.

Third, we extend the extant literature of EV toward stakeholders and its impact on GSCM and EMS perspectives during Covid-19. We empirically test the moderating role of EV to enable the link between EMS adoption and market competitiveness. Our findings revealed that with an increased level of EV to stakeholders, EMS impact on market competitiveness will be increased, otherwise, EMS alone will deliver a confusing message to stakeholders regarding the implementation of GSCM and EMS practices. Our result confirmed the recent finding of Marshall et al.Marshall et al. (2016), which determined that GSCM and EMS implementation will not work effectively until stakeholders do not have any information reading such practices. We tested the proposed call for research in GSCM, EMS, and market competitiveness perspective during Covid-19 and contributed to extant literature of EV on-going debate. To the best of our knowledge, none have tested EV relations on the association between EMS and market competitiveness.

6.2. Practical implications

First, our study provides evidence that GSCM will help the organization to implement EMS effectively and achieve market competitiveness. The manager should consider EMS, which may be the best mechanism during Covid-19 to retain in the market as well get benefit from GSCM, thereby market competitiveness. Second, the organization should adopt a formal EMS system because it is directly linked with market competitiveness, where market competitiveness is associated with higher employment, best working conditions, market reputation to achieve goals. Our results further revealed that organizations having EMS more successfully get benefit from the implementation of GSCM practices. Certified EMS implementation is a key path to getting market

competitiveness and policymakers should consider it seriously, especially during an uncertain situation like Covid-19. Third, the current study provides useful insight into the practitioners' actual GSCM practice along with BDA-AI, which will assert a more effective impact on EMS within the organization. The practitioner should adopt BDA-AI and get useful information from the raw data. It will further help to improve the GSCM practices and sustainability. Finally, we provide empirical evidence and suggest that EV to stakeholders is more likely to enhance the effectiveness of EMS and thereby market competitiveness. If organizations are using GSCM and EMS, it must be communicated with stakeholders which will enhance the trust and reputation in the market. To improve the EMS, the manager should communicate with the stakeholders and use their feedback to avoid confusing information which will ultimately reward the organizations.

6.3. Limitation and future research call

Despite contributions, our research also has limitations in generalizability. For example, the current study is based on self-report data which perhaps suffered from CMB. Although, we ruled out all the possibilities of CMB data, however, we will suggest using secondary data along with primary data to make sure the causal relation is intact. Second, we use BDA-AI and EV at the first and second stage moderators respectively, future research should examine other moderators such as the transactive memory system of stakeholders, absorptive capacity of employees and managers. It will provide a new avenue and thoughtful insight for scholars as well policymakers to change EMS design. Third, we use GSCM as a two-dimensional construct such as internal and external GSCM practices. Future research should discover other variables such as green innovation, green products, and green marketing to examine the specific impact on EMS. Moreover, we used GSCM as a practice variable, future research should investigate it from a capability perspective and try to address the specific issues raised by the stakeholder in implementing the GSCM such as an imbalance between actual and disclosed practices. Fourth, we use the BDA-AI role to examine the impact of GSCM on EMS, it would more interesting if future research examines the role of leadership of logistics or SC managers and top management commitment in implementing the GSCM. Such factors provide another stream of thoughts, e.g., how organizational factors can influence the long-term strategy of the firms. Fifth, the data was collected from a European country (i.e., Italy), which may limit the generalizability of the current study. Future research should consider comparative studies across countries to better understand GSCM practices during Covid-19. Finally, our study discusses GSCM practices for enhancing market competitiveness through EMS in the presence of BDA-AI and EV. Given the scope of our study, we did not focus on how consumers would adopt green and sustainable products that may cost more than non-green products. Therefore, future research should examine, if consumers are willing to pay more for sustainable products than for low-cost products (assuming sustainable practices may cost more than unsustainable ones), to what extent this means to market competitiveness.

7. Conclusion

The Covid-19 pandemic has adversely influenced the integration and coordination of SCM to manage customer and supplier demand. The current study provides a sustainable mechanism and highlights the adoption of GSCM and EMS that increases the market competitiveness even during the pandemic. Using the survey method and SEM analytical approach, specifically, the present study examines whether EMS affects the relationship between GSCM practices and market competitiveness. Moreover, the findings of this study help us to comprehend the moderating role of BDA-AI and EV in managing the GSCM practices. Current research provides thoughtful insights for the supply chain practitioners, policymakers, managers, and scholars that organizations should opt for formal EMS, BDA-AI, and EV to achieve market competitiveness, even in times of crisis such as Covid-19.

Ethics approval

We got approval from our institution.

Consent to participate

Participants are consent to participate.

Consent for publication

Not applicable.

Authors' contributions

Conceptualization (Q.Z., B.G., A.L.); Data curation (A. L.); Formal analysis (A.L.); Funding acquisition (Q.Z.); Investigation (A.L., Q.Z., B. G.); Methodology (A.L., Q.Z., B.G.); Project administration (Q.Z.); Resources (Q.Z.); Software (A.L., Q.Z.); Supervision (Q.Z.); Validation and Visualization (A.L., Q.Z., B.G.); Writing – original draft (A.L., Q.Z., B.G.); Writing – review & editing (Q.Z., A.L., B.G.)

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Declaration of competing interest

The authors declare that they have no competing interests.

Appendix-A

Items/Construct

Internal GSCM Practices	[40]
1. Waste reduction practices	
2. Energy use reduction practices	
3. Water use reduction practices	
4. Reduction of the emissions practices	
External GSCM Practices	

(*continued*)

5. Supplier selection based on sustainability competencies (e.g. clean technologies, environmental programs)
6. Supplier selection based on current sustainability performance
7. Supplier selection based on their sustainability reputation
8. Supplier selection based on the sustainability certifications
9. Supplier selection based on their capability of developing sustainable products

Environmental Management Systems   [76]

10. EMS procedures are formally documented
11 Company has a formal EMS
12. Formal department responsible for environmental affairs
13. EMS procedures are widely available
14. Formal reporting position between environmental group and executives
15. Environmental performance formally tracked and reported
16. Top management support for environmental performance
17. Environmental information is tracked and monitored regularly
18. Environmental performance is periodically captured and summarized
19. Environmental issues, policies, and procedures are included in training
20. Goals have been developed and implemented which report environmental performance
21. Environmental position is given prominent visibility in annual report
22. People within firm consider EMS highly effective
23. Firm has a well-developed EMS data base for tracking and monitoring environmental issues
24. People outside the firm consider the EMS highly effective
25. Environmental performance results widely distributed
26. Causes of environmental problems are focused on
27. Environmental achievements given visibility in annual reports
28. Reasons for environmental problems are attacked

Environmental Visibility   [40]

29. Suppliers
30. Distributors
31. Final consumers
32. Customers
33. Shareholders
34. Employees/Unions
35. Industrial associations/NGOs
36. Local community
37. Mass media
38. National, European, International regulatory institutions
39. Banks
40. Scientific community/research institutions

Big Data Analytics-Artificial Intelligence   [39].

41. Use of advanced analytical techniques (e.g., simulation, optimization, regression) to improve decision-making
42. Use of multiple data sources to improve decision-making
43. Use of data visualization techniques (e.g., dashboards) to assist decision-makers in understanding complex information
44. Deployment of dashboard applications/information in communication devices (e.g., smartphones, computers) of the green supply chain process

Market Competitiveness   [73].

45. Easier access to the capital market because of a lower environmental risk
46. Increase in sale turnover
47. Increase in market share of your main products
48. Increase in exports
49. Improved capacity to win public tenders

Appendix-B. ,

Factor Loading and Cross-Loadings

Constructs	Items	EMS	EV	GSI	MC	BDA-AI	GSE
Environmental Management System	EMS4	**.894**	.143	.086	.090	.054	-.063
	EMS2	**.880**	.138	.147	.102	.051	.038
	EMS11	**.874**	.189	.087	.094	.098	-.034
	EMS3	**.863**	.059	.125	.141	.009	.066
	EMS6	**.861**	.077	.140	.073	.072	.035
	EMS5	**.799**	.088	.120	.114	.149	.042
	EMS10	**.788**	-.003	.114	.116	.021	.035
	EMS15	**.774**	.151	.141	.142	.140	.047
	EMS12	**.774**	.100	.138	.145	.084	.077
	EMS14	**.732**	.250	.150	.061	.072	-.048
	EMS17	**.727**	.178	.161	.058	.008	.056
	EMS1	**.725**	-.022	.081	.128	.095	-.006
	EMS13	**.721**	.179	.138	.134	.062	.051
	EMS7	**.720**	.116	.171	.157	.027	.026
	EMS8	**.716**	.203	.171	.061	.184	.004
	EMS16	**.714**	.190	.189	.177	.058	.019
	EMS18	**.712**	.223	.217	.163	.147	-.025
	EMS19	**.698**	.041	.272	.187	.206	.002

(*continued*)

Constructs	Items	EMS	EV	GSI	MC	BDA-AI	GSE
Environmental Visibility	EMS9	**.675**	.094	.175	.112	.118	.083
	EV2	.276	**.896**	.098	.014	.218	.028
	EV8	.295	**.874**	.048	.030	.089	.047
	EV6	.252	**.873**	.029	.022	.082	.066
	EV12	.286	**.870**	.052	.016	.086	.041
	EV10	.259	**.865**	.042	-.010	.107	.059
	EV4	.378	**.846**	.058	-.053	.209	-.004
	EV5	.274	**.707**	.081	.065	.074	-.024
	EV9	.217	**.752**	-.071	.081	.006	-.066
	EV3	.324	**.749**	.016	-.031	.071	.047
	EV1	.392	**.746**	.086	-.071	.127	-.059
	EV11	.165	**.578**	.107	.016	.068	.041
	EV7	.238	**.484**	.042	.026	.075	-.021
External green supply chain management	GS2	.312	.056	**.842**	.147	.167	.008
	GS1	.268	.063	**.835**	.116	.144	-.021
	GS3	.290	.006	**.834**	.176	.101	.014
	GS5	.309	.001	**.810**	.142	.151	.000
	GS4	.207	.169	**.803**	.203	.103	.003
Market Competitiveness	MC2	.260	.036	.194	**.888**	.094	-.009
	MC3	.315	.013	.198	**.875**	.069	-.055
	MC4	.309	-.014	.152	**.862**	.107	-.022
	MC1	.242	.002	.179	**.848**	.064	-.039
	MC5	.143	.061	.129	**.804**	.144	.101
Big data analytics-artificial intelligence	BDA2	.143	.111	.180	.083	**.824**	.014
	BDA4	.101	.061	.075	.037	**.823**	.053
	BDA3	.149	.080	.203	.099	**.810**	-.017
	BDA1	.213	.086	.089	.079	**.700**	-.043
Internal green supply chain management	GSE3	.017	.017	.014	.001	-.111	**.894**
	GSE4	.024	.068	-.050	-.022	.079	**.842**
	GSE2	.037	.124	.001	-.063	.067	**.822**
	GSE1	.083	-.064	.035	-.008	-.032	**.810**

Note: EMS = Environmental Management System, EV = Environmental Visibility, GSI = Internal Green Supply Chain Management, MC = Market Competitiveness, BDA-AI = Big Data Analytics-Artificial Intelligence, GSE = External Green Supply Chain Management.
Note: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

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