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Review

Sustainable Ground Transportation and the E-Commerce Revolution: Innovations and Challenges at the Intersection

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Abstract: This review paper offers a comprehensive exploration of the symbiotic relationship between sustainable ground transportation and the dynamic realm of e-commerce. It delves into the critical intersection of environmental sustainability, technological innovation, and the evolving landscape of online commerce. This review synthesises cutting-edge technologies and strategies aimed at reducing energy requirements and environmental impacts in ground transportation. It explores advancements in lightweight materials, aerodynamics, and alternative fuels, emphasising their potential to mitigate the environmental footprint of vehicles. Additionally, the transition towards zero-emission vehicles, including battery-operated and fuel-cell vehicles, is analysed, taking into account both short-term and long-term outlooks. Simultaneously, the paper delves into the evolving landscape of e-commerce, which has become an integral part of modern consumer behaviour. It investigates the influence of e-commerce on ground transportation practices, emphasising the importance of efficient logistics, last-mile delivery, and sustainability in meeting the demands of the digital commerce era. By providing a holistic view of the challenges and opportunities at the nexus of sustainable ground transportation and e-commerce, this review paper offers valuable insights for researchers, policymakers, and industry stakeholders striving to shape a more sustainable and responsive future for ground transportation in the digital age.

Keywords: e-commerce law; online transaction rights; sustainability; ground transportation; consumer protection

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1. Introduction

In today's digital age, the symbiotic relationship between sustainable ground transportation and the dynamic realm of e-commerce has taken centre stage. This review paper explores the critical intersection of environmental sustainability, technological innovation, and the evolving landscape of online commerce. The convergence of these forces presents challenges and opportunities that warrant a comprehensive examination [1], especially in the last mile, due to external costs increasing because smaller (and therefore less efficient) vehicles are used that cover longer and more difficult routes. On the other hand, customer traffic using individual motorisation is limited. The world of e-commerce has undergone a profound transformation, influencing consumer behaviour and business strategies. Consumer perceptions and attitudes towards online transactions are shaped by a complex interplay of factors, including e-commerce laws and regulations [2]. The United Kingdom, for instance, has a set of e-commerce laws that impact online business strategies, and these laws have direct implications for companies engaged in dropshipping [3]. As internet

access proliferates, the market for online transactions continues to expand, creating new possibilities for businesses and consumers alike.

In the wake of the COVID-19 pandemic, the importance of online transactions has surged globally [4]. Lockdowns and social distancing measures prompted a fundamental shift in consumer habits, driving people to rely on online modes of sending and receiving money. The convenience and safety offered by online transactions became especially crucial during times when physical interactions were restricted. This shift accelerated the adoption of online transactions in the United Kingdom, reflecting a broader trend towards the digitalisation of commerce [5].

Apart from the development of e-commerce, sustainable ground transportation has popularly attracted the attention of scholars over the last decade. The drive towards sustainable ground transportation is primarily fueled by environmental concerns, particularly the need to mitigate climate change and reduce pollution. This aspect is closely linked with technological advancements. Innovations in electric vehicles, battery technology, and renewable energy sources are crucial to making sustainable transportation viable and more efficient. This synergy between environmental goals and technological progress is central to the research and development in this field [6].

Governments worldwide are increasingly recognising the economic benefits of sustainable transportation, such as long-term cost savings and job creation in the green economy. This recognition has led to the implementation of policies and incentives to promote sustainable options, like investments in electric vehicle infrastructure and subsidies for electric vehicle purchases. Scholars are interested in how these economic and policy measures can accelerate the adoption of sustainable transportation solutions and their impact on the broader economy [7].

Rapid urbanisation has escalated the need for efficient sustainable public transit systems. Researchers are focusing on how to integrate sustainable transportation methods into the urban fabric, making them more accessible and appealing to the public. This aspect also involves studying societal behaviour and preferences to understand and influence how people choose transportation, aiming to shift the public towards more sustainable options [8].

This article is structured as follows: Section 2 clarifies the methodology of the whole paper and gives a statistical analysis on the literature related to both sustainable ground transportation and e-commerce. Section 3 offers a comprehensive narrative literature review on sustainable ground transportation, delving into cutting-edge technologies and strategies to reduce environmental impacts and energy requirements in ground transportation. Section 4 presents a narrative literature review on e-commerce, exploring the evolving landscape of online commerce and its influence on consumer behaviour. Section 5 examines the influences of e-commerce on sustainable ground transportation practices, emphasising the importance of efficient logistics, last-mile delivery, and sustainability in the digital commerce era. Finally, Section 6 provides conclusions synthesising the challenges and opportunities at sustainable ground transportation and e-commerce intersections, offering valuable insights for researchers, policymakers, and industry stakeholders. By shedding light on consumer perceptions and attitudes towards their rights regarding online transactions, this research contributes to the ongoing discourse on enhancing consumer protection in the ever-evolving e-commerce landscape.

2. Methodology and Data Analysis

The process of conducting a literature review involves several key steps as shown in Figure 1. Initially, researchers begin by setting clear research objectives and identifying relevant keywords and search terms related to their topic of interest. Next, a comprehensive literature search is conducted using databases like Scopus, aiming to retrieve a wide range of academic articles and studies, as shown in Table 1. Articles found based on "sustainable AND ground AND transportation AND e-commerce" are used for upcoming analyses. Once the literature is collected, an analysis of the subject areas

and development trends within the retrieved articles is carried out, categorising them into thematic groups to identify common threads and recurring themes. Finally, the most critical phase involves synthesising the information gathered from the selected literature, where connections between the various sources are drawn, key findings are highlighted, and a coherent narrative discussion is presented that not only summarises the existing knowledge but also contributes to a deeper understanding of the research topic in the upcoming three sections. Extra articles are also used to facilitate the encyclopaedia for readers from various backgrounds.

Figure 1. The literature methodology.

Table 1. Publication counts with keywords on Scopus.

Keywords	Scopus Count
e-commerce	184,051
sustainable AND ground AND transportation	31,564
sustainable AND ground AND transportation AND e-commerce	503

The growing research interests in e-commerce and sustainable ground transportation can easily be noticed, as shown in Table 1. Counts of publications are conducted based on the two topics. By assessing Scopus, which is one of the most popular databases of the peer-reviewed literature [9], it is noticed that more than 500 publications on sustainable ground transportation are related to e-commerce.

As the relationship and correlation of the areas are close and complex, such as increased demand for efficient delivery systems [10] and reduction in carbon footprint [11], this paper aims to identify, examine, and differentiate various types of e-commerce data that are acknowledged, used, and reported in the study of sustainable ground transportation. This research study can provide a broader understanding regarding the developments of these studies by both statistical analyses with a narrative literature review on both areas and their intersection to review and propose potential developments.

From 2003 to 2024, research in the fields of sustainable ground transportation and e-commerce spanned across various subject areas, reflecting a multidisciplinary approach to these topics as shown in Figure 2. The prominent subject areas with a substantial number of articles (equal to or more than 12) included social sciences, engineering, computer science, business, management and accounting, and environmental science. These subjects collectively contributed to the comprehensive exploration of sustainable ground transportation and e-commerce. Additionally, other disciplines like economics, decision sciences, energy, and mathematics also made significant contributions to the literature, highlighting the interdisciplinary nature of these research areas. It is noteworthy that this research was conducted with a multidisciplinary perspective, and the diverse range of subject areas demonstrated the broad academic interest and relevance of both sustainable ground transportation and e-commerce.

Over the span of two decades, from 2003 to 2024, there has been a discernible evolution in the scholarly discourse surrounding sustainable ground transportation and e-commerce, as shown in Figure 3. In the early years, minimal research activity was observed, with only one or a few articles published annually. However, as the years progressed, both fields garnered increasing attention. Notably, from 2018 onwards, there was a substantial surge in publications, signifying a growing interest in these topics. The pinnacle of research output occurred in 2022, with 117 articles on sustainable ground transportation and 117 on e-commerce. It is worth mentioning that the data collection for this overview was

conducted in January 2024, and the final count for that year may not yet be conclusive. Nevertheless, the trends from 2003 to 2022 demonstrate the rising significance of sustainable transportation and e-commerce in academic research.

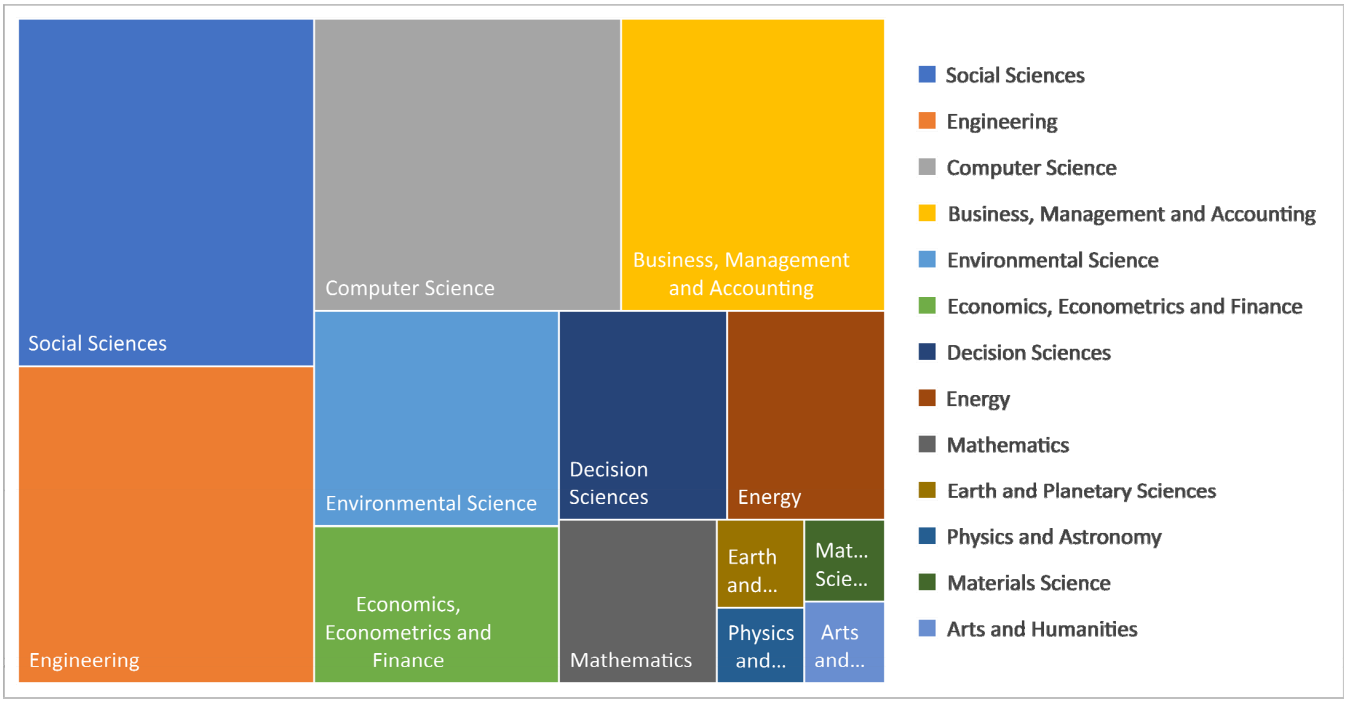

Figure 2. A tree map of subject areas of articles related to both sustainable ground transportation and e-commerce.

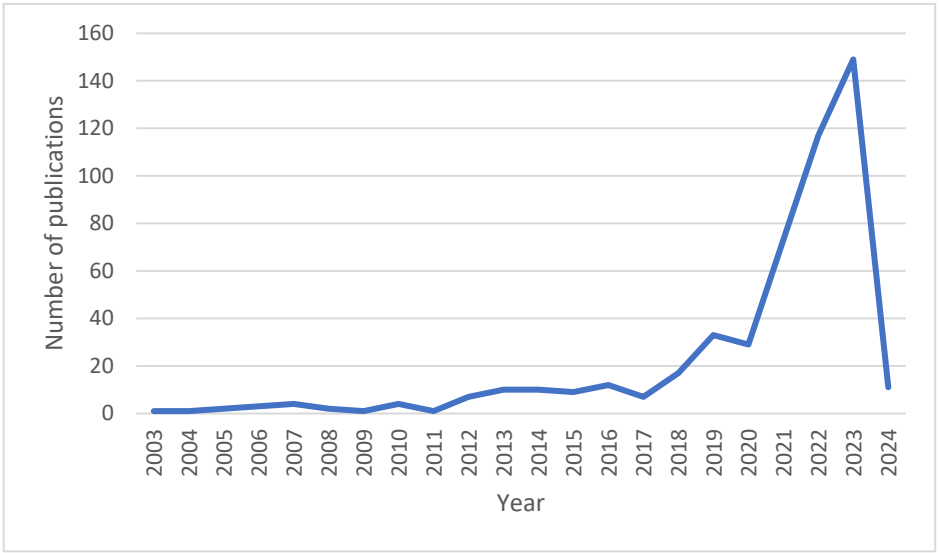

Figure 3. The trend of articles related to both sustainable ground transportation and e-commerce.

3. Literature Review on Sustainable Ground Transportation

Ground transportation has played a vital role in urbanisation and rapid industrialisation. Road networks are flexible and convenient ways of transportation, as well as connecting railways, harbours, airports, and cities. A rising perception of the different adverse effects of automobility, like urban sprawl, public health degradation, safety issues, social and traffic inequities, and pollution, has induced an international movement to use sustainable ground transportation practices [12]. Developing a sustainable ground trans-

portation system is vital and may generate a related contribution to achieving various sustainable development goals created by the 2030 Agenda for Sustainable Development [13]. In response, sustainable ground transportation inclines towards air quality improvement, emission reduction, and energy conservation [14].

Nevertheless, sustainable ground transportation remains a hot topic of interest because researchers, industrial practitioners, and local communities employ best practices for social progress, economic efficiency, and environmental protection. This is one of the extensive programs that utilises transportation investments to produce a sustainable ground transportation infrastructure, for instance, cross-sea bridges, super expressways, and high-speed railways. Sustainable ground transportation may be described as the capacity to encourage the mobility needs of freight, information, and people in such a way that minimises negative impacts on the environment [15]. As such, decision makers and scientists globally are concentrating on sustainable ground transportation to decrease CO_2 emissions and balance the climate. Lau et al. [16,17] suggested an energy shift to reduce CO_2 emissions and employ electric vehicles in road transportation. Epicoco and Falagario [13] addressed that the railway is identified as one of the most sustainable and environmentally friendly transport modes, and increasing the efficiency of regional and local railways is a prime sustainable ground transportation goal. In addition, local cities and authorities are introducing different policies and plans for actions and strategies to encourage sustainable ground transportation. These include promoting public transportation, limiting car use, redesigning streets to improve active transportation, and combining transportation planning and land use [18]. However, Jelti et al. [14] pointed out that implementing sustainable ground transportation may face barriers due to a lack of community support, funds, and advanced technologies. Also, institutional barriers directly impact the implementation process of sustainable ground transportation, with policymakers lacking awareness of the different benefits of sustainable ground transportation. Therefore, Yang et al. [8] also suggested developing a testing and scoring mechanism to assess buyers' behaviours on green vehicle purchases.

4. Literature Review on E-Commerce

Through the theoretical perspectives, the entire approach of e-commerce has been mentioned clearly in this chapter, and the literature gap has also assisted this research in providing effectiveness. The narrative literature review typically involves summarising and synthesising the findings of the studies, highlighting their strengths and weaknesses, and identifying any gaps in the literature. By reviewing the literature with related keywords, several types of literature are noticed: the impact of e-commerce on business, change in consumer attitude towards online transactions, government legislation followed by the e-commerce sectors, influence of modern technologies in developing online transactions, influence of COVID-19 on developing online transactions, and consumer perception of uncertainties and risks associated with an online transaction.

4.1. The Impact of E-Commerce on Business and Change in Consumer Attitude towards Online Transactions

E-commerce has successfully developed across the global business market to help organisations boost their performance. Apart from that, the promotion process has also been changed massively through the help of e-commerce marketing. Digital technologies such as social media are the most used e-commerce platforms that have successfully assisted multiple organisations in exploring their business [19]. Similarly, Nayati Utami et al. [20] argued that technological advancements are considered the most influential factor that might resolve this issue. Considering modern business approaches, e-commerce has significantly developed the business culture of multiple organisations across the global business market. Significantly, e-commerce profoundly impacts organisational health development across the global business market. Great control and customer engagement, along with the entire business development regarding profit and sales, will also come across

through enabling e-commerce in the business. Several other ways also ensure benefits for the organisation through changing the traditional mode of return and delivery system of a particular product.

There are also several antecedents and consequences for e-commerce that have effectively impacted business in many ways. As Sombultawee [21] stated, e-commerce has a profound impact on changing the mood of online transactions in business. The apparent purpose of the research was to identify the consequences and antecedents of e-commerce specifically for small and medium enterprises (SMEs) across the UK business market. At the time of this discussion, it was noticed that the "Theory of Reasoned Action" effectively promoted organisational health. Therefore, the author utilised a modified yet practical UTAUT framework in the research to incorporate the existing pieces of knowledge and IT resources.

On the contrary, Kirby-Hawkins et al. [22] stated that e-commerce is considered the fastest-developing sector across the UK business market. The primary aim of the paper was to signify the geographical aspects of e-commerce and its activities that will be highly concerned with the transactions between the business and the consumers rather than consumer-to-consumer and business-to-business.

Recently, the UK's most used e-commerce payment gateways have been Visa and MasterCard. Ali et al. [23] stated the negative aspects of using technologies in e-commerce businesses. The authors added that in this context, consumers are affected by fraud activities when using mobile-based or browser-based mobile internet. The UK industry report stated that, at the end of the year 2022, e-commerce will have successfully made up 20.4% of international retail sales. However, only 10% of e-commerce organisations utilise word-of-mouth advertising over social media platforms for their initial advantages. According to Šaković Jovanović et al. [24], e-commerce impacts sales development for a particular organisation. The paper here postulates that e-commerce's severe impact on firms' performance is not direct and, at the same time, it is necessary to examine the fact using the mediating factors. The "ordinary least-squares model" has been employed in research to collect data from direct sources. In this particular aspect, there is an apparent necessity for applying the theory of reasoned action so that the business's behavioural aspects can be adequately determined [25].

4.2. Change in Consumer Attitude towards Online Transactions

Consumer behaviours have a deep impact on organisations regarding their health and wealth. In this aspect, consumer behaviour has a massive influence on the progress of the business. An organisation that has effectively incorporated the demands of its customers achieves the most effective outcome in business. In this particular context, multiple effective service platforms have been assisting the UK business market in appropriately exploring payments. For example, Stripe, Worldpay, and Opayo are the three major e-commerce platforms that might assist organisations in developing their transaction processes [26]. The massive development of online marketing and online transactions across the global market, specifically across the UK, has successfully changed the motives of the entire process. In this context, the deadly pandemic has massively impacted business organisations, forcing them to face changes in consumer attitudes. According to Baicu et al. [5], the deadly coronavirus pandemic affected the global economy. The essential purpose of the paper was to investigate the significant impact of the deadly COVID-19 pandemic crisis on consumer behaviours. To achieve the goal of the research, the authors surveyed different country markets. The research results highlighted among different people the concerning variable points regarding the deadly effect of the pandemic.

The literature on consumer attitudes and perceptions of their rights regarding online transactions highlights the impact of the COVID-19 pandemic on the economic sector and consumer behaviour. Sayyida et al. [27] noted that the pandemic has led consumers to use online channels to reduce face-to-face contact with marketers, but customers still prefer to see, touch, and feel products directly in physical stores. Transaction cost theory helps

analyse how organisations have successfully adapted to the pandemic and overcome the critical situation. Sent and Kroese [28] suggest that consumers' limited rationality and opportunistic behaviours can be incorporated into the theory to improve business outcomes. The UK e-commerce market has witnessed the growing popularity of payment gateway services such as Stripe, which offers flexibility and control over payment pages [29]. UK consumers increasingly prefer digital or wallet payment methods, as they save time and money. However, the absence of a suitable payment method significantly contributes to cart abandonment rates. Access to financial infrastructure is crucial for tech-driven companies seeking to embed payments within their platforms, as Westermeier [30] discussed. The COVID-19 pandemic created various sales and marketing issues for UK organisations, and Chetioui et al. [31] proposed an integrated model that mediates the effect of relative advantages on attitudes towards online shopping.

An increase in the use of online transactions has led to an increased chance of the emergence of various types of new fraud techniques affecting people's trust in online fraud. The fear of identity theft, fraud, or hacking can make some consumers hesitant to purchase or share their personal information online. As suggested by Park et al. [32], an increase in the chance of online fraud is one of the most significant regions that can affect trust in online transactions. Recently, especially post-COVID-19, there's been a surge in phishing scams leading to account hacking. These scams trick users into disclosing personal information, causing significant losses. This increase aligns with greater digital reliance during and after the pandemic. This has led to a decrease in people's trust in online transactions.

Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, they need to state that they will be provided during review. They must be provided prior to publication. Interventional studies involving animals or humans and other studies that require ethical approval must list the authority that provided approval and the corresponding ethical approval code.

Dwidienawati et al. [33] suggested in their journals that users can use some ways to reduce the chance of fraud. For instance, the author suggests not using public WiFi systems to carry out any online transaction mode as this can increase the chance of hacking accounts. In addition, using a secure online platform is necessary to protect transactions and sensitive data. Additionally, a user must have a regular watch on the account transaction and be aware of any inauthentic transactions from accounts.

Additionally, a strong password must be set to help reduce the chance of data leakage and fraud. Finally, e-commerce facilities must be developed through technologies to provide more compelling insights into organisational performance [15]. These are some of the suggested ways to be followed to reduce the chance of data leakage and increase the chance of security in online transactions.

Therefore, in this aspect, the theories for regional action need to be implemented to understand the cause and effect behind the online transaction that can be implemented. There are various issues regarding online transactions, such as data theft and delay. However, most people have shifted to online transactions for daily use due to the lockdown and the spread of COVID-19 in the UK, which has led to a vast increase in the number of users carrying out online transactions.

4.3. Government Legislation Followed by the E-Commerce Sectors

The UK has significantly developed technologies, and the impact of these technologies is primarily positive. Organisations from SMEs to larger-sized organisations have successfully run their businesses as they have effectively followed governmental regulations. The Legal Metrology Act of 2009 and the Consumer Protection Act have successfully assisted UK organisations in developing their businesses. Apart from that, organisational activities such as marketing, sales, and consumer engagements have also developed for the organisations that use these mentioned legislations in their business.

The commercial laws of the UK are all aligned with these particular areas. Worldpay provides better reliability and customer experiences and costs the minimum fee of 2.75% +GBP 0.20. It also demands a monthly renewal of GBP 19, which is relatively low for organisations considering this platform for a transaction. Stripe does not demand a single pound, whereas Opayo payment demands GBP 25 for every 300 transactions from the organisations that use the payment gateway. In this particular aspect, Costa and Castro [34] stated that the recent emergence of e-commerce has successfully created a light shifting paradigm in the international markets. This particular revolutionary framework relies upon the progress of the technologies that have extensively conveyed a modern era of commerce. According to the authors, businesses utilise digital marketplaces to stay competitive and relevant. Suddenly, the online buying process has become an integral part of the daily routines of companies. According to Rana et al. [35], recognising the barriers to e-commerce is also necessary for SMEs across the UK to improve their transaction facilities. Flexibility and accessibility successfully make the internet an ideal platform for modern consumers.

Small and medium organisations predominate in almost every organisation, generating employment, sustainability, and income. On the other hand, Podorova-Anikina et al. [36] mentioned that the recent pandemic has been a primary reason for the significant development of e-commerce in business. Therefore, the research here provides a detailed competitive analysis of the impact of the pandemic on the mentioned e-commerce market in different countries.

The authors have successfully established the prerequisites for adequately intensifying the development of the e-commerce market. The internet has played a remarkable role in developing and growing mobile device users and social networks, gradually weakening the offline retail sectors. The implemented state policy regulating the e-commerce market has significantly accelerated the organisation's transaction process. Most medium-sized organisations have been seen to follow the Consumer Protection Act in business. The advantage of e-commerce over the proper formation of the offline retail market is established. According to Ferencz [37], the evolving digital economy increases productivity and drives proper growth in the entire economy, but it might be threatened by differences in the national rules along with the potential fracturing of the global internet.

4.4. Influence of Modern Technologies in Developing Online Transactions

Considering the modern business scenario, technologies have made a huge difference in business. Technology-based organisations in the modern business market are the ones to achieve success quickly and effectively. Modern technologies such as artificial intelligence (AI), cloud computing, and many more have a considerable capacity to improve the health of organisations [6]. Organisations have adopted these technologies to achieve massive customer support and improve sales and marketing.

Significantly, in the UK business market, technological advancement has changed the mode of marketing for technology-based organisations. However, as per the view of Al-Saedi et al. [38], technologies have modified rather than changed how businesses are conducted, fundamentally assisting both organisations and customers simultaneously. The research was conducted to determine the most frequent factors extending the "Unified theory of acceptance" and utilising technology for different payment methods. On the contrary, Riley and Klein [39] explained that companies must make modern transaction methods available to customers. The purpose of the research was to recognise the use of customers' retail channels online. The study determined that tracking capabilities and trust are crucial to the consumer along with online reviews that directly influence the online purchasing attitude (through extension intention).

In this particular context, mobile payment has become a popular aspect that might assist organisations and customers in establishing a clear transaction format. At the beginning of the twentieth century, organisations across the UK successfully enabled modern technologies in their transaction purposes, where customers had two payment choices. The B2B businesses are the most affected parts of the UK business market regarding interna-

tional transactions [27]. Most retail markets across the UK have started using this mobile payment technology, which has smoothened their transactions. Organisations have been noticed to implement the strategic marketing theory in their business. Zeithaml et al. [40] stated that implementing the entire theory would be an excellent choice for developing the organisation's payment method. The authors also signified that the development of the knowledge of marketing based on business theories could be generalised effectively and could improve the organisation's health. The benefits of engaging the theories in business will assist in incorporating opportunities for creating relevant marketing knowledge.

On the contrary, Leonidou et al. [41] stated that stakeholders effectively impact organisational health development through the proper process of transactions. Through a systematic review of the previous 27 papers, this research has successfully provided a multi-dimensional integrative framework that specifies the stakeholder engagement process in the business. In conclusion, this research also derives the implications of the stakeholders and their management for the theory and, at the same time, the proper practice of the entrepreneurs.

4.5. Influence of COVID-19 on Developing Online Transactions

The emergence of COVID-19 has increased the importance of online transactions throughout the world. As opined by Almajali and Hammouri [4], COVID-19 has changed people's money-sending and money-receiving habits. They shifted their preference to online transaction modes in their daily life. It allows them to send or receive money without physically contacting each other. Especially after 2021, when the UK government imposed a nationwide lockdown, it increased issues for ordinary people as they could not buy products for their daily needs. Hence, as a result, they started to shift towards the online process for their daily needs. Similarly, Baicu et al. [5] stated a rapid increase in the use of online transitions in the UK, especially after COVID-19. This happened clearly because most people preferred online transitions over physical transactions to avoid the spread of COVID-19 in the UK. Hence, this led to an increase in online transactions in the country.

The lockdown imposed due to COVID-19 led to an increase in people's tendency to use online shopping for their basic needs. Baicu et al. [5] stated in their journals that people prefer online shopping when buying groceries and other products. Therefore, it led to increasing e-commerce in the UK and other countries. It helped them receive products sitting at home, reduced the chance of being affected by COVID-19, and helped them follow other norms such as social distancing measures and restrictions on in-person shopping. As a result, most people prefer to use online transactions in the case of shopping and other activities in the UK.

Chronopoulos et al. [42] suggested in their journals that the pandemic has also increased the adoption of digital payment procedures in some nations where money has been reduced. In the UK, for example, the government encouraged citizens to use digital payment methods to reduce the risk of transmission. However, the increased use of online transactions has also led to a boost in defrauding activity. It has been noticed that the most recent approach of payment through e-commerce has assisted organisations in attracting more customers to their business [43]. Cybercriminals have seized the benefit of the pandemic to launch phishing episodes and other frauds aspired at swiping personal and economic data from gullible customers.

Hence, in that aspect, the transaction cost theory can be applied to help interpret the critical factors relating to the region behind traction. Furthermore, this theory helps to understand the cause behind the shift in people's transactions, especially after COVID-19. While this has brought comfort and flexibility to people, it has also made new challenges for cybersecurity and fraud deterrence in the UK and other countries. Currently, most businesses in the UK have adopted an online transaction mode as it is convenient for both the clients and the business itself and can even increase the business's revenue to a certain level.

5. Influences of E-Commerce on Sustainable Ground Transportation

The recent surge in e-commerce, magnified by the COVID-19 pandemic's impact on shopping habits, has significantly reshaped last-mile logistics and urban transportation. With global lockdowns, the necessity for last-mile deliveries in urban areas soared, leading to more trucks in cities and a notable increase in greenhouse gas emissions [44]. With sustainable ground transportation still being the minority, this rise in e-commerce has become a critical factor in transportation-related emissions [45]. One approach involves integrating electric vehicles into the home delivery system, offering a solution to reduce noise and gas emissions. However, this transition faces challenges such as consumer preferences, technological limitations, lack of sufficient recharging infrastructure, high costs of electric vehicles, and issues with their range and recharging times [46,47]. For investigating and optimising the situation, there are four research directions mentioned by scholars.

Firstly, e-commerce has spurred the adoption of electric and low-emission vehicles in delivery fleets. Companies are shifting towards electric vans, scooters (Figure 4) and bikes (Figure 5), to minimise the emissions linked to delivery activities [16]. This trend bolsters sustainability efforts and propels electric vehicle technology and infrastructure enhancement [8].

Figure 4. E-scooters in Liverpool.

Secondly, the high demand for delivery efficiency in e-commerce has catalysed the evolution of route optimisation and logistics strategies [17,48]. These advancements focus on reducing travel distances and fuel consumption, reducing emissions, and easing urban traffic congestion.

Thirdly, e-commerce provides a compelling alternative to conventional shopping, potentially diminishing the frequency of individual shopping trips using personal vehicles [49]. This shift can reduce overall traffic and emissions, but it introduces a new challenge: managing the rise in delivery vehicles. Finding a balance between these dynamics is crucial for sustainable urban development [50].

Figure 5. A cargo bikes in Amsterdam.

Lastly, e-commerce platforms are increasingly leveraging parcel lockers to facilitate consolidated deliveries. This approach involves grouping multiple orders to centralised locker locations, significantly reducing delivery trips [51]. This strategy makes the delivery process more efficient and markedly reduces the transportation sector's carbon footprint, contributing to the advancement of sustainable ground transportation in the e-commerce era [52].

These four directions highlight the intricate interplay between e-commerce growth and sustainable urban transport, underscoring the need for innovative solutions in last-mile delivery to meet the dual goals of efficiency and environmental sustainability.

6. Conclusions

In conclusion, the dynamic interplay between sustainable ground transportation and e-commerce, particularly pronounced during the COVID-19 pandemic, has brought challenges and opportunities. This relationship is in constant flux, necessitating ongoing advancements and adjustments to meet emerging needs. Embracing innovation and prioritising sustainability is critical to ensuring this synergy positively impacts economic growth and environmental protection. These approaches lead to a more resilient and efficient future for both sectors. To further enhance this relationship, future research could explore various avenues.

The rapid growth of e-commerce has driven the transition towards electric vans, bikes, and scooters in delivery fleets. This shift holds significant potential for enhancing sustainability in urban transportation. Future research in this area could delve into advancing the technologies behind electric vehicles, improving the infrastructure necessary to support them, and comprehensively understanding the overall impact of these changes on environmental sustainability. Studies could also explore the challenges faced, such as consumer preferences, technological limitations, the current inadequacy of recharging infrastructure, the high costs associated with electric vehicles, and issues related to their range and recharging times.

Efficient delivery is a cornerstone of e-commerce, leading to significant logistics advancements, particularly in route optimisation. There is a growing need to investigate methods to minimise travel distances and fuel consumption. This research could focus on developing advanced algorithms and technologies for route planning and delivery scheduling. The aim would be to decrease emissions significantly, contributing to environmental sustainability while easing urban traffic congestion.

E-commerce presents a viable alternative to traditional shopping methods, which has the potential to reduce the frequency of personal vehicle use for shopping purposes. Research in this area is essential to understand how the rise in delivery vehicles can be effectively managed. Studying the balance between reducing personal vehicle trips and increasing delivery traffic is essential. This research could help formulate strategies for sustainable urban development, considering the changing consumer behaviour patterns and the resultant impact on urban transportation networks.

Using parcel lockers by e-commerce platforms is a growing trend aimed at consolidating deliveries. This strategy significantly reduces the number of delivery trips needed by grouping multiple orders into centralised locker locations. Future research could investigate how this approach makes the delivery process more efficient and substantially reduces the transportation sector's carbon footprint. This line of inquiry could explore the logistical, environmental, and social implications of this delivery method and how it contributes to the advancement of sustainable ground transportation in the era of e-commerce.

These research directions will help dissect the complex relationship between e-commerce and sustainable ground transportation, highlighting the need for innovative solutions in last-mile delivery to achieve efficiency and environmental sustainability.

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