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The Impact of Strategic Agility on Environmental Sustainability: The Mediating Role of Digital Transformation

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Abstract: In today's ambiguous and complicated business environment, businesses are required and mandated to be agile and think rapidly. Building on the theory of dynamic capability, the present research makes a strong argument that strategic agility is a key component in managing continuous change effectively. The primary objectives of this research are to examine the impact of strategic agility on digital transformation and environmental sustainability and to explore the effect of digital transformation on environmental sustainability. Additionally, we investigated the indirect impact of strategic agility on environmental sustainability via digital transformation. To achieve these objectives, a self-administered questionnaire was developed and used to gather data from 284 managers in manufacturing companies in Jordan. To test the research hypotheses, structural equation modeling (SEM) with Amos 24.0 was used. The results revealed that strategic agility positively impacted both digital transformation and environmental sustainability. Furthermore, digital transformation positively affects environmental sustainability. Additionally, digital transformation partially mediated strategic agility's impact on environmental sustainability. The results indicate that businesses use and employ strategic agility as a means to achieve the desired results, and it may operate as a proactive facilitator and catalyst, allowing organizations to optimize most of their available resources, achieve the desired digital transformation, and accomplish the expected environmental sustainability objectives and results.

Keywords: digital transformation; dynamic capability theory; environmental sustainability; strategic agility

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1. Introduction

Existing issues and challenges concerning the ecosystem and environmental sustainability, like global warming, environmental air and water pollution, and scarcity of resources, have placed business organizations under tremendous pressure to develop ecologically sound plans and strategies [1,2]. Environmental sustainability is a cornerstone of sustainability, requiring that initiatives designed to meet current needs must not damage the ecosystem, and environmental quality should be protected for the greater good and advantage of present and future generations [3]. Consequently, the stakeholders and the market are exerting additional pressure on businesses to initiate, develop, and adopt environmentally friendly and ecologically sustainable processes, practices, and activities [4,5].

Strategic agility describes the capacity of businesses to respond and adapt to the ever-changing, dynamic needs of customers and clients [6], which is usually achieved via developing skills and the development of abilities. Consequently, environmentally friendly practices are something that businesses should generally promote, adopt, and consider in conjunction with the notion of strategic agility. Organizations must constantly

review, evaluate, and revise their strategies and operational plans to adapt to changes brought about by Industry 4.0 and the ongoing technological advancement in digital and information. Agility, as described in the literature, refers to a business's capacity to modify and quickly adjust its tactics, procedures, operations, strategies, and activities as a reaction to external threats, challenges, changes, and environmental issues [7]. Particularly crucial to the notion of strategic agility is the theory of dynamic abilities and the capabilities concept, which is described as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" [8].

Nowadays, business organizations in every sector and industry are compelled and mandated to continually review, evaluate, and revise their competitive advantage sources to adapt to dynamic, rapid advancements and the ever-evolving business environment.

Digital technology is advancing at a rapid pace, which is causing significant and substantial changes in the industrial ecosystems; these developments have many facets and affect society, the economy, and organizations, especially when developing new "products", "services", "innovation processes", "business models", and the "nature of business operations" [9–11]. As stated by Gong and Ribiere (2021), digital transformation is "a fundamental change process enabled by digital technologies that aim to bring radical improvement and innovation to an entity to create value for its stakeholders" [12].

The existing literature has provided limited evidence of the impact of strategic agility on environmental sustainability [13–15]. In addition, some prior research and studies have explored the influence of strategic agility on digital transformation [16–19]. However, the majority of these studies and investigations were conducted in developed countries. Furthermore, most previous studies in the manufacturing industry focused on large companies. To the best of our knowledge, no such studies have been conducted in Jordan. Additionally, prior studies have not examined the mediating effect of digital transformation on the impact of strategic agility in environmental sustainability.

The manufacturing industry is one of the significant and major business sectors in Jordan and contributes approximately 30% to the gross domestic product (GDP) [20]. However, since 2010, exports of manufacturing companies in Jordan have been declining by 0.5% annually [21]. One reason for this decline is that manufacturing companies in Jordan face several problems and challenges related to their environmental performance [22]. Many Jordanian manufacturers do not comply with the strict environmental requirements imposed by foreign countries and, therefore, do not qualify to export to those countries. Accordingly, achieving environmental sustainability is crucial for Jordanian manufacturing companies.

By addressing the gaps discussed above, the current study aims and attempts to add and contribute to the existing body of knowledge. It examines the impact of strategic agility on digital transformation and environmental sustainability in the manufacturing firms in Jordan. The majority of manufacturing firms in Jordan are classified within the small- and medium-sized businesses (SMEs) category. Therefore, this study adds valuable insights into the anticipated effects within the settings of SMEs in a developing nation that faces distinct economic and environmental challenges. Furthermore, the current investigation adds to the literature by investigating how digital transformation mediates the strategic agility relationship with environmental sustainability. In particular, the following specific research questions (RQ) are posed:

RQ1. What impact does strategic agility have on digital transformation and environmental sustainability?

RQ2. How does strategic agility affect environmental sustainability through the mediating effect of digital transformation?

The remaining portion of this research is structured as follows: A review of the research-related literature is presented in Section 2. The study's theoretical background and the development of the research hypotheses are described in Section 3. The method used in this study is detailed in Section 4. Section 5 presents the statistical analysis and testing of the hypotheses, followed by a discussion of the study's findings in Section 6. Lastly, Section 7 presents the study's conclusions, managerial implications, and limitations.

2. Literature Review

2.1. Strategic Agility

The widespread adoption of Industry 4.0 technology on a global scale has forced business organizations to make substantial developments and modifications to how they conduct their operations and how they interact with other parties and the surrounding environment [23]. The utilization of an agile approach has become increasingly important in the present business environment that is characterized by higher levels of dynamism and constantly altering, diverse sources of changes, which are necessary for constant adaptation to opportunities and challenges from the external environment [24]. According to Yaseen and Al-Samhouri (2023), business organizations can improve and enhance their performance by developing and utilizing their dynamic capabilities and agility [25].

Strategic agility is essential and a critical factor in the survival of businesses in a dynamic, rapid, and constantly evolving business environment. According to Shams et al. (2021), "responsibility", "capability", "adaptability", and "speed" are only a few of the critical and necessary qualities that strategic agility portrays [26]. Kumkale (2016) asserts that businesses need strategic agility and it is crucial to argue that it provides them with a distinct advantage edge and solid leads [27].

Strategic agility has attracted greater attention and investigation in the literature. The strategic agility concept has garnered significant attention as a means of addressing the need and necessity to adapt swiftly to the ever-changing and dynamic business environment conditions and the aspiration of maintaining competitive qualities [28,29]. According to Doz (2020), strategic agility is a firm's aptitude, capacity, and preparedness to recognize and adjust to the ever-evolving and dynamic business environment and respond swiftly, easily, and rapidly [30]. Strategic agility, as described by Ayoub and Abdallah (2019), is a business organization's capacity to adjust to shifts and alterations in the business environment of the industry, both internally and externally, and the ability to maintain competitiveness by identifying and seizing opportunities as well as recognizing potential threats and preventing or averting them [6]. Being a leader or a fast follower when developing new products, services, and customer solutions is what it means to be a strategically agile business. According to several researchers and scholars, a fundamental element of strategic agility involves a business or organization's capability to promptly and efficiently respond and adapt to alterations and shifts in the environment that affect the industry in which it conducts its operations [31,32].

2.2. Digital Transformation

In recent times, academics, practitioners, and researchers have started paying increasing attention to digital transformation. Due to the digital transformation of businesses across all industries, businesses are struggling and find it challenging to continually keep up with the ongoing advances and alterations [33]. Even though innovation is considered essential and valuable for resolving anticipated risks and issues and exploring novel opportunities for businesses [34], for a firm, digital transformation is now considered a crucial necessity for their operations [35]. The swift development and rapid advancements of technologies in information and communication have resulted in a paradigm shift and radical evolution; this has urged businesses to prioritize digital transformation as a strategic goal due to these advancements [36,37]. Accordingly, the need for digital transformation has grown even more as a result of the introduction of innovations and the complexities and unstable shifts and changes that are occurring and emerging in the environment of business [38,39].

Previous research defines "digital transformation" as a shift in how businesses use emerging technology to generate significant business changes, improve customer experiences, boost operational effectiveness, or develop novel models of digital business that add value to the organization [11].

As the distinctions and boundaries separating the digital and physical worlds begin to erode and blur, technological breakthroughs and digital transformation are compelling

and require business organizations to reassess and reconsider their value generation strategy [40]. The capacity to modify and alter their business systems and models is vital for established firms that compete with inventive and revolutionary digitally entrepreneurial businesses [41]. Businesses, the economy, and society are all impacted by the complex concept of "digital transformation" [10,42,43]. Furthermore, it is largely impacted by external variables such as new rivals, developing technology, and changing customer preferences [11].

2.3. Environmental Sustainability

Global leaders, scientists, governments, and policymakers have found that the sustainability of the environment is one of the most challenging issues to deal with in recent times [22]. In response to environmental difficulties, challenges, issues, and concerns, firms are concentrating their business activities on environmental sustainability [44]. To be able to achieve and attain environmental sustainability, it is imperative to fulfill current wants and needs without jeopardizing or endangering the capacity of the forthcoming generations to fulfill their needs, wants, and desires [45].

The broad definition of "sustainability", originally outlined in the published "Brundtland Report" of the "World Commission on Environment and Development (WCED)" in 1987, serves as the basis for the contemporary interpretation of the term. Sustainable development is "achieving a balance between economic growth, environmental protection, and social well-being while meeting the demands and needs to satisfy the requirements of the present generation without jeopardizing the ability of future generations" [46]. Therefore, it describes an approach that encourages the recognition of developed policies and strategies that take into consideration both the observed immediate impacts of sustainability and the observed long-term effects of sustainability development [47]. Many ideas have since evolved, such as the concept of environmental sustainability that emphasizes biodiversity preservation while sustaining economic and social development [48].

In today's business environment and the contemporary business climate of decision-making processes, environmental sustainability has emerged as a crucial and vital component [49]. In preventing damage to humans, sustainability of environment measures seek "to improve human welfare by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, to prevent harm to humans" [50]. Nowadays, business organizations of all sizes and in all industries devote significant attention to environmental sustainability; they prioritize it, significantly emphasize it, and give it a lot of attention [51]. Organizations are encouraged to look for a compromise between the benefits and drawbacks of the environment, economy, and society [52]. As stated by Alayón et al. (2017), lowering emissions, minimizing waste, and increasing the utilization of renewable resources may all contribute to environmental value [53]. The phrase "sustainable business practice" describes business practices and policies that are profitable, sustainable, ecologically conscious, and ethically sound. According to Ghosh and Barman (2021), sustainable economic values can be generated by business practices that prioritize social responsibility, environmental friendliness, and ecological awareness in their operations [54].

3. Theoretical Framework and Hypotheses Development

3.1. Dynamic Capability Perspective

Dynamic capabilities are "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" [8]. The theory of dynamic capability argues that businesses are conducting their operations in a dynamic environment that is constantly changing and ever-shifting, which leads them to build dynamic competencies and capabilities to adapt to environment alterations and changes [8,55,56]. Al-Omoush et al. (2022) and Martins (2023) contend that a firm's resilience and survival are largely dependent on its capacity to build diverse competencies and develop dynamic capabilities [57,58].

Organizations must build dynamic capacities in the context of sustainability to seize opportunities and identify challenges associated with sustainability. Strategic agility is an essential and crucial dynamic capability that can assist firms in achieving sustainability goals and objectives. The firm can respond and adapt to alterations, modifications, and changes by sensing, identifying, recognizing, and seizing opportunities in the environment [8,59].

In addition, the theory of dynamic capabilities explains the link and relationship between digital transformation and strategic agility [8,29]. The capacity and capability of businesses to react rapidly and adapt to shifts, alterations, and transitions in their environment is known as strategic agility. The term "digital transformation" describes the utilization and application of digital technology, which are thought to enhance and strengthen the organization's productivity, innovation, and long-term competitive advantages. Therefore, by helping the organization to digitalize its business processes and attain the capability of digitalization, strategic agility has the potential to support the organization's transformation and additionally improve environmental sustainability [18,29].

Essentially, the theory of dynamic capability offers a framework for comprehending how businesses and firms might cultivate the dynamic competencies and capabilities needed to react to modifications, adjustments, alterations, changes, and shifts in the environment to achieve the objectives and goals of sustainability. Strategic agility is a vital and essentially needed dynamic capacity that helps business organizations react swiftly and successfully to sustainability-related issues. Particular competencies associated with digital transformation may additionally help businesses to be proactive in response to environmental changes and improve the role the firm plays in reacting swiftly and efficiently to sustainability.

This study utilizes the insights from dynamic capacity theory to enhance the theoretical framework depicted in Figure 1 and subsequently conducts empirical testing for the hypothesized relationships among strategic agility, digital transformation, and environmental sustainability. Thus, we argue that the dynamic capability of strategic agility can enable business organizations to achieve high levels of digital transformation and environmental sustainability. Improved digital transformation is expected to further enhance environmental sustainability.

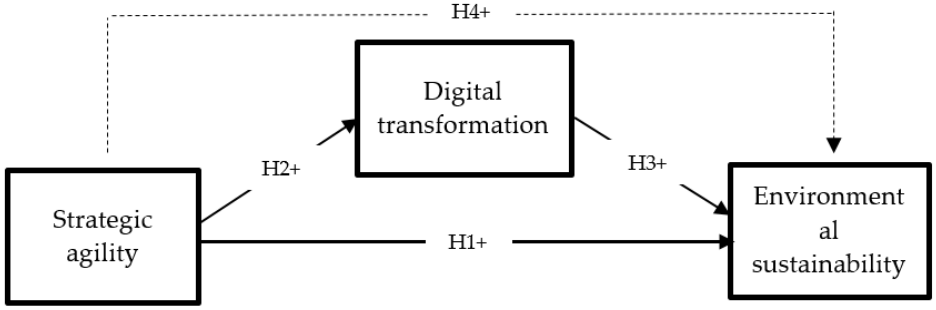

Figure 1. Research model.

3.2. Strategic Agility and Environmental Sustainability

Agility is the capacity to rapidly, affordably, and precisely reorganize and rearrange available resources, as well as everyday operations and activities, to deal with changing circumstances and uncertainty [13,56,60,61]. Agility, according to Shams et al. (2021), is a business's capability to offer a range of goods and services promptly, efficiently, and affordably; on the other hand, environmental sustainability describes the organization's attempt and effort to increase recycling rates and reduce its negative impact on the environment [26].

Environmental sustainability necessitates organizational policies, plans, and practices for protecting and preserving the planet's natural resources. Environmental sustainability encompasses reuse and recycling, ecologically friendly packaging, employing ecologically friendly resources and supplies, and other environmental protection measures [59]. Agility allows and encourages immediate and ongoing adaptations that add value in novel

ways; it can be extremely important in solving environmental issues, concerns, and challenges [13–15], for example, decreasing waste and its adverse or detrimental impacts on the natural environment through resource adoption and improving the efficiency of production [13]. Business organizations can benefit from integrating both of these concepts in numerous ways, like increasing product diversity, time and cost reductions, and survival in a competitive marketplace with a minimal negative impact on ecological systems [15]. Furthermore, this significantly affects the business organization's reputation and its relations with stakeholders; thus, the following hypothesis can be proposed:

H1. *Strategic agility will directly and positively affect environmental sustainability.*

3.3. Strategic Agility and Digital Transformation

Digital transformation has increasingly become a fundamental process that is essential for transformation at the level of the organization; it allows the organization to utilize and examine digital technologies as a means to redevelop its business models and systems [17]. It promotes digital innovation to modify and reorganize the means and methods by which companies run their operations, which sparks creativity, as well as developing novel and innovative business systems and models, processes, and procedures.

Strategic agility is necessary for the successful and effective execution, accomplishment, and achievement of the digital transition and transformation. Strategic agility is a method that needs to be used for managing risks and unforeseen organizational changes because digital transformation involves dramatic organizational multilevel changes [62]. As a result, strategic agility turns into a crucial requirement for an organization to thrive and survive in unpredictably volatile and intensely competitive contexts [18,63]. The operations and network of an organization must be agile; this allows for the quick dissemination of innovative ideas and novel concepts among organizational members and encourages experimentation and taking calculated risks while the organization undergoes digitization and digital transformation. Strategic agility can boost an organization's creative endeavors and innovative practices by adapting rapidly to shifts, changes, and modifications in the form of novel services, goods, and operations [64,65]. The fundamental components and core of digital transformation are capability-driven achievements and final results, such as new business models, competitive advantages, and significantly changed or radically altered goods or services. Digital transformation, according to Henriette et al. (2015), involves more than simply shifts and changes in technology [19]. Numerous factors and components must be coordinated at both the strategic and operational levels to facilitate or allow a major change or a significant shift or transformation to take place. Organizations can develop superior services and goods in response to increasing rivalry by using agility to find and gather pertinent knowledge [16]. In an ever-changing, dynamic, quick-paced, and evolving business environment, the achievement of the goal of digital transformation is essential for organizations' survival. As a result, firms must have the ability to react swiftly and actively in response to alteration and shifts at different levels. Thus, the following hypothesis can be developed:

H2. *Strategic agility will positively affect digital transformation.*

3.4. Digital Transformation and Environmental Sustainability

High levels of digitization will yield improved, "real-time event management" and more accurate data, both of which improve the sustainability of the environment [66]. Environmentally friendly product development and manufacturing could be fully realized with the help and support of technological advancement in Industry 4.0 and digital transformation [67,68]. Thus, digitization and technological improvements of Industry 4.0 may eventually result in more environmentally friendly and sustainable manufacturing systems and processes [69]. Zhang et al. (2019) noted that the utilization and implementation of digital transformation and technologies in Industry 4.0 greatly improved and significantly

enhanced environmental sustainability and performance in a refrigerator production facility [70]. Furthermore, Stock et al. (2016) asserted that digitalization may contribute to the efficient distribution of resources including "materials", "electricity", and "water" [71]. According to data released by the "Organization of German Engineers", digitization can reduce emissions of carbon by 20% and boost resource efficiency by 25% [72]. Digital technologies provide manufacturing management with an increased ability to respond to environmental issues and sustainability [66,73].

Digital capabilities including smart robotics increase productivity, effectiveness, and efficiency in manufacturing while maintaining product quality; this leads to increased resource efficiency, decreased waste, and improved sustainability for the environment [74]. Moreover, additive manufacturing, which is an advanced level of digital transformation, improves resource efficiency, reduces waste, and boosts environmentally sustainable performance [2,75]. Similarly, Lee (2020) and Junior et al. (2018) highlighted and emphasized the enormous potential advantages and benefits for the environment that can be derived from "carefree operation", the use and the utilization of digital technology like "big data", "cloud computing", and "industrial artificial intelligence (IAI)" platforms [76,77]. However, some researchers and scholars argue that the advancement and implementation of digital technology lead to higher energy and resource consumption and ultimately increased production of waste [66,78,79].

H3. *Digital transformation will positively affect environmental sustainability.*

3.5. Mediation Effect of Digital Transformation on Strategic Agility and Environmental Sustainability Relationship

The previous discussion highlighted the immediate effect and direct impact of strategic agility on environment suitability (e.g., [13–15]). Interestingly, however, the question arises: Does strategic agility alone influence environmental sustainability, or can an additional variable provide a more comprehensive explanation for this relationship?

Viewed from the dynamic capability theory perspective, strategic agility has a distinct capacity and ability to empower companies to integrate and restructure their resources in response to changing environmental conditions [80]. In this context, digital transformation serves as the strategic reconfiguration of digital technologies and resources. When strategic agility is applied to enhance environmental sustainability, digital transformation acts as a facilitator, effectively configuring digital resources to promote environmental sustainability [81]. Furthermore, digital transformation, through communication tools, automation, and advanced data analytics, enhances the efficacy of strategic agility in improving environmental sustainability. In addition, increased levels of digitalization resulting from the implementation of strategic agility are expected to enhance firms' and businesses' sustainability by improving their abilities to produce novel goods and services in a more ecologically responsible and environmentally friendly manner [82]. Also, digital technologies provide the ability to enhance operational effectiveness via real-time access to and the collection of process data, energy management, and resource consumption. Thus, the following hypothesis can be proposed:

H4. *Digital transformation mediates the relationship between strategic agility and environmental sustainability.*

4. Method

4.1. Sample

The study population of the current research constituted a total of 1795 manufacturing businesses and firms in Jordan [20]. According to Krejcie and Morgan (1970), the size of the representative sample for this population's characteristics is 317 respondents [83]. To achieve and attain the required and necessary sample size, the authors distributed 400 questionnaires in total. In this study, individual manufacturing firms were used

as the study's unit of analysis. From each company, one respondent was targeted to participate in the research. These targeted respondents held managerial positions, including operations managers, supply chain managers, IT managers, and others, and possessed adequate knowledge of the study's constructs. Data collection spanned approximately two months from April to June 2023. The survey questionnaires were prepared in an online version and sent by email, WhatsApp, and LinkedIn to the targeted managers. In one instance, one of the authors hand-delivered the survey questionnaires to the managers. Ultimately, 298 questionnaires were returned and completed. However, 14 questionnaires had missing data, thus rendering them invalid and unusable. As a result, 284 questionnaires were accepted and utilized, representing a response rate of 71%. Table 1 displays the demographic information and the organizational details of the participating companies.

Table 1. Participating companies and respondents' profiles.

Category	Frequency	Percentage (100%)
Gender		
Male	246	86.6
Female	38	13.4
Total	284	100.0
Job position		
Operations Manager	89	31.3
IT Manager	78	27.5
Supply Chain Manager	67	23.6
Plant Manager	27	9.5
Others	23	31.3
Total	284	100.0
Industry type		
Electrical and electronics	50	17.6
Machinery and hardware	49	17.3
Food	46	16.2
Chemical	37	13.1
Rubber and plastic	34	11.9
Textiles and garments	32	11.3
Pharmaceutical	20	7
Others	16	5.6
Total	284	100.0
Number of employees		
Less than 100	113	39.8
100–less than 200	120	42.3
200–less than 300	37	13
300 and above	14	4.9
Total	284	100.0
Experience		
Less than 5 years	75	26.4
5–10 years	113	39.8
11–15 years	58	20.4
16 years and above	38	13.4
Total	284	100
Educational level		
Two-year diploma	18	6.3
Bachelor degree	220	77.5
Postgraduate studies	46	16.2
Total	284	100.0

4.2. Measures

To attain the objectives of the present research, the authors developed a self-administered questionnaire to gather the required and necessary primary data. The three constructs used in this study were adopted from the prior related literature published in the English language. Accordingly, the English language was used to prepare the initial version of the survey

questionnaire. After that, the authors translated the questionnaire into the Arabic language. Upon the adoption of the measurement scales, the authors assured that all the scales demonstrated satisfactory levels concerning validity and reliability in the original articles. Hence, the content validity of the adopted measurement scales was presumed. To measure strategic agility, eight items were adopted from Tallon and Pinsonneault [65], Queiroz et al. [84], and Haider and Kayani [85]. To measure digital transformation, five items were adopted from Nasiri et al. [86]. Environmental sustainability was measured using eight items adopted from Bamgbade et al. [87] and Ajibike et al. [88]. To confirm and ensure face validity, the questionnaire of the survey was evaluated and assessed by six business administration academics and six managers from manufacturing companies with adequate experience and knowledge regarding research variables. Modifications were made according to the feedback and comments that were received.

For the items of the three research constructs, participants were required to assess their level of disagreement or agreement with the given statements using a Likert scale with five points, where 1 represents "strongly disagree" and 5 represents, "strongly agree".

5. Analysis of Data and Results

5.1. Measurement Model Assessment

To evaluate and assess the unidimensionality and convergent validity of the measurement scales of the present research, appropriate validity tests were carried out. Moreover, two reliability tests, namely Cronbach's alpha and composite reliability coefficient, were performed. Confirmatory factor analysis (CFA) was carried out and executed using Amos 24.0 to confirm, verify, and validate the unidimensionality of the measurement scales to assess and analyze the fit of the study's measurement model. Survey items with loadings of factors greater than 0.50 were kept as they supported the unidimensionality of variables utilized in the present study [89]. Only one question item was deleted because it did not meet this criteria. Next, the fit indices for the measurement model were evaluated and they revealed acceptable levels (χ^2 = 1046.537, df = 593, χ^2/df = 1.764, CFI = 0.923, TLI = 0.916, IFI = 0.925, RMR = 0.042, and RMSEA = 0.043). In addition, all the retained question items demonstrated statistically significant levels ($p < 0.01$), providing, thus, additional evidence for the convergent validity [45]. In addition, the computed average variance extracted (AVE) values for the three measurement scales used in the current investigation all surpassed the cutoff value of 0.50 [90].

Once the validity of the study's constructs was ensured, reliability analyses of Cronbach's alpha and CR were performed. Both tests showed satisfactory reliability levels above the recommended threshold of 0.70 for the three measures, signifying that the constructs are reliable, credible, and internally consistent [89,90]. Table 2 presents the study's measurement scales' validity, reliability, and measurement items.

Table 2. CFA results and measurement items.

Item Code	Measurement Item	Mean	Std.	Factor Loading [a]	Cronbach's Alpha	Composite Reliability	AVE
	Strategic agility (Tallon and Pinsonneault [65]; Queiroz et al. [84]; Haider and Kayani [85]).	3.92	0.674	0.861		0.886	0.528
SA1				0.693			
SA2				Deleted			
SA3				0.746			
SA4				0.688			
SA5				0.735			
SA6				0.773			
SA7				0.768			
SA8				0.675			

Table 2. *Cont.*

Item Code	Measurement Item	Mean	Std.	Factor Loading [a]	Cronbach's Alpha	Composite Reliability	AVE
	Digital transformation (Nasiri et al. [86])	4.03	0.564		0.857	0.849	0.532
DT1				0.648			
DT2				0.661			
DT3				0.792			
DT4				0.786			
DT5				0.746			
				0.648			
	Environmental sustainability (Bamgbade et al. [87]; Ajibike et al. [88])	3.86	0.712		0.875	0.892	0.511
ES1				0.665			
ES2				0.692			
ES3				0.753			
ES4				0.746			
ES5				0.616			
ES6				0.827			
ES7				0.628			
ES8				0.764			

[a] In the CFA model, standardized factor loadings are displayed.

5.2. Results

In testing the research hypotheses, structured equation modeling (SEM) using Amos 24.0 was utilized. SEM is acknowledged to provide proper and accurate results concerning mediation effects (e.g., Gunzler et al., 2013; Alkhaldi and Abdallah, 2022) [91,92]. The results of the mediated model (the model that includes the independent, mediating, and dependent variables) showed that strategic agility directly and positively affected environmental sustainability ($\beta = 0.360$, $p < 0.01$); thus, support for hypothesis H1 is provided. Next, hypothesis H2, which indicated that strategic agility positively affects digital transformation, was tested. The results revealed that strategic agility significantly and positively impacts digital transformation ($\beta = 0.487$, $p < 0.01$); accordingly, the second hypothesis, or H2, was supported. Digital transformation's impact on environmental sustainability proved also to be positively significant ($\beta = 0.447$, $p < 0.01$), thus supporting the third hypothesis or H3.

The technique of bootstrapping resampling was used to test the fourth hypothesis H4 regarding the indirect impact of strategic agility on environmental sustainability via digital transformation [93,94]. Utilizing confidence intervals with a bias correction of 95% (CIs), bootstrap samples totaling 5000 were chosen according to Hayes's (2017) recommendations [47]. Based on the procedures of the bootstrapping resampling technique, if the two intervals (upper and lower) do not include a value of zero, regarding the mediating effect, the alternative hypothesis is accepted [93]. The results demonstrated that strategic agility has an indirect impact of 0.218 on environmental sustainability via digital transformation. Consequently, hypothesis H4 was accepted because both the upper and lower confidence interval limits ranged from 0.286 to 0.156 and did not contain a value of zero. It should be noted that digital transformation partially mediated strategic agility and environmental sustainability relationships. This was concluded based on the fact that the impact of strategic agility on environmental sustainability without including or considering the mediating variable (the total impact) was positively significant ($\beta = 0.578$, $p < 0.01$). After adding the mediating variable to the model, strategic agility's impact on environmental sustainability was reduced but was still positively significant ($\beta = 0.360$, $p < 0.01$), demonstrating that the mediating effect is only partial [95]. Table 3 presents a summary of the results of the hypotheses testing.

Table 3. Results of the hypotheses test.

Hypothesis	Path	Model without Mediator	Mediated Model	Bias-Corrected Bootstrap 95% Confidence Interval		Result
				Lower	Upper	
H1	SA → ES	0.578 **	0.360 **			Supported
H2	SA → DT	NE	0.487 **			Supported
H3	DT → ES	NE	0.447 **			Supported
H4	SA → DT → ES	NE	0.218 (indirect effect)	0.156	0.286	Supported

Notes: ** $p < 0.01$; NE: not estimated; SA: strategic agility, DT: digital transformation, ES: environmental sustainability.

6. Discussion

The study's findings indicate a direct effect of strategic agility and positive impacts on environmental sustainability; therefore, strategic agility can play a substantial role in addressing environmental issues and concerns to minimize waste and negative environmental effects. This is because it fosters quick and ongoing adaptations and enables immediate and continuing changes that add value in novel ways, which concurs with the findings of other previous research. Additionally, addressing environmental issues and concerns has a substantial effect on the business's reputation and its relationships with stakeholders. This result aligns with findings from prior studies (e.g., [13–15]). Notably, while the majority of past research has been conducted in developed nations, our study is situated in a small developing country. It is noteworthy to emphasize and highlight that the vast majority of Jordanian manufacturing companies fall into the SME category. This is evident from the demographic and organizational information table, with over 95% of participating companies having fewer than 200 employees. This is a distinctive feature of our study as previous research predominantly focused on larger companies. Our findings indicate that the advantages of strategic agility in achieving high levels of environmental sustainability extend beyond large manufacturing companies in developed countries. SMEs in developing countries can similarly reap these benefits through the successful implementation of strategic agility principles.

The findings also demonstrated that strategic agility positively affected digital transformation. This result can be reconciled by recognizing that organizations that adopt strategic agility grounded in developing achievable scenarios, based on spotting changes in their business environment caused by technological breakthroughs and advancements, have more opportunities to improve their digital transformation and achieve success. Businesses that are more strategically agile will be more capable of responding quickly and better equipped to react rapidly to alterations, modifications, changes, and shifts brought on by customer preferences, business practices of rivals, and advancements in technology that frequently occur in a volatile environment. Strategic agility is a business organization's capacity to anticipate shifts in the environment and swiftly stimulate its resources to respond to these alterations; it allows the organization to explore possibilities with digital technology and change its business processes and is an essential strategy for managing unexpected alterations, changes, and threats as a means to execute and achieve a successful digital transformation. This is consistent with prior works [17,18,62,63].

Furthermore, the research findings revealed that digital transformation positively impacted environmental sustainability, which is the third finding. Digital transformation provides business organizations with the ability to analyze the data about the environment and forecast changes so that manufacturing companies may quickly alter their operations and respond to changing conditions, offer novel goods and services, and consider new ways to use existing products, thus leading business organizations to accomplish their environmental sustainability objectives and goals more effectively and efficiently. This result is consistent with data published by The Organization of German Engineers, which claimed that digitization could lead to a 25% increase in the efficiency and utilization of resources and a 20% reduction in emissions of carbon (Kopp and Lange, 2019) [72]. This

is also in line with the findings of Oláh et al. (2020) and Song and Moon (2017), which showed that production systems are now equipped with a solid foundation for increased responsiveness due to the prevalence of the "Internet of Things (IoT)", the "Cyber-Physical System (CPS)", and "real-time process monitoring of resource" use [66,73], and findings of Ghobakhloo (2020), which revealed that intelligent robots increase the effectiveness of industrial production while maintaining product quality, which leads to improved resource utilization and reduced waste [74]. This result also aligns with the works of Chang et al. (2017) and Ford and Despeisse (2016), which stated that, through specialized "just-in-time production" systems that are closer to the consumer, additive manufacturing increases the utilization of resources and decreases waste [2,75].

Lastly, it has been observed that the relationship between strategic agility and environmental sustainability is partially mediated by digital transformation. To our knowledge, this study is the first to explore the indirect impact of strategic agility on environmental sustainability via digital transformation. Thus, it contributes to and adds to the body of existing knowledge by emphasizing the pivotal role that strategic agility plays in strengthening and accelerating digital transformation, which, in turn, further boosts environmental sustainability. This implies that strategic agility alone may not be sufficient to attain superior levels of environmental sustainability, and manufacturing companies have to direct the efforts of strategic agility to boost the levels of digital transformation so that environmental sustainability levels will be maximized. However, our result should be interpreted with caution as the partial mediating effect revealed implies that digital transformation may not be the sole supporting factor in the strategic agility/environmental sustainability relationship. Other factors, such as green practices, circular economy, and organizational culture, can also influence the extent to which strategic agility translates into improved environmental sustainability practices. All in all, our result points to the essential role of digital transformation as a mediator, indicating that organizations aiming to enhance their environmental sustainability should not solely focus on strategic agility but should also strategically invest in digital technologies and capabilities. These technologies facilitate real-time data collection, analysis, and decision making, enabling organizations to proactively identify and address environmental challenges.

7. Conclusions, Managerial Implications, and Limitations

7.1. Conclusions

This research aimed to examine and investigate the impact of strategic agility on digital transformation and environmental sustainability. It also addressed a notable gap in the literature by exploring the indirect impact of strategic agility on environmental sustainability via digital transformation. Importantly, the study's unique value lies in its context of a developing country, where the majority of the manufacturing companies represented in the present study sample belonged to the SMEs category. Consequently, a theoretical model incorporating strategic agility, digital transformation, and environmental sustainability was developed to investigate the direct and indirect hypothesized relationships. As such, this research adds to the current body of knowledge by examining and exploring the proposed relationship and addressing the identified research gaps.

Our results revealed that strategic agility has a direct, positive, and significant impact on environmental sustainability. Additionally, it was found that strategic agility positively and significantly affected digital transformation. Furthermore, digital transformation had a positive and significant impact on environmental sustainability. A noteworthy finding was that the relationship between strategic agility and environmental sustainability was partially mediated by digital transformation. This implies that strategic agility influences environmental sustainability in two ways: directly and indirectly through digital transformation, which acts as a mechanism through which strategic agility partially affects environmental sustainability.

The results imply that manufacturing companies with higher levels of strategic agility are more inclined to invest in and harness digital technologies and capabilities to further

enhance their environmental sustainability initiatives. The adoption and use of digital technology and related practices are expected to lead to more efficient resource utilization, waste reduction, and enhanced environmental management, aligning with sustainability objectives. In summary, the dynamic capability of strategic agility indirectly influences environmental sustainability, mediated by digital transformation. Our findings suggest and imply that in the context of industrial businesses in a small developing country, strategic agility serves as an effective dynamic capability that can instigate organizational changes, resulting in improved performance and technology-driven outcomes.

Business organizations can use strategic agility as a tool to help them reach their objectives. To put it another way, strategic agility may serve as a proactive facilitator and catalyst, allowing organizations to optimize most of their available resources, achieve the desired digital transformation, and accomplish the expected environmental sustainability objectives and results.

7.2. Managerial Implications

This research provides valuable insights and practical implications for managers and practitioners. Firstly, managers in manufacturing companies should recognize the advantages and benefits of embracing strategic agility as a dynamic capacity that strengthens and improves their company's competitive advantage. By adopting a mindset focused on dynamic capabilities, managers can better understand the importance of strategic agility as a crucial ability necessary to navigate highly uncertain and evolving business environments while addressing concerns and challenges related to environmental sustainability. Secondly, the results underscore the critical role of strategic agility as one of the primary capabilities for manufacturing companies to initiate their journey toward achieving environmental sustainability goals and objectives. Cultivating and championing the principles of strategic agility, such as the capability to sense, identify, and seize opportunities, and integrating these principles with digital transformation strategies empower managers to enhance efficiency, drive innovation, develop new goods, services, and business models, reduce waste, effectively address environmental sustainability concerns, and have a positive effect and influence on the environment. Thirdly, managers in manufacturing companies must recognize that while strategic agility can enhance the implementation of environmental sustainability practices, it alone may not suffice to achieve exceptionally high sustainability standards. To attain superior levels of environmental sustainability, managers should channel the capabilities of strategic agility toward bolstering the implementation of digital transformation. This, in turn, will further elevate environmental sustainability to the desired levels. Leveraging digital technologies empowers managers to gain valuable insights and make informed decisions and enables them to identify emerging trends, enhance operational efficiency, and contribute to a more sustainable future.

7.3. Limitations and Suggestions for Future Research

Like other research papers, there are limitations to this study that could be addressed in future studies and investigations. First, only one mediating variable, digital transformation, was considered in the current study. Although this mediating variable proved to be essential and partially mediated the impact of strategic agility on environmental sustainability, other variables can further enhance this relationship. Therefore, future research and studies can examine and explore the mediating impacts of other variables such as green practices, circular economy principles, and environmental management systems. Second, due to Jordan's limited number of industrial businesses within a single industry type, we targeted industrial firms from various types. However, different industry types have distinct characteristics in terms of agility levels, environmental impacts, and levels of digital technology adoption. Hence, future studies should focus and concentrate on one industry type to clarify industry-specific features and contexts, thereby enhancing the generalizability of the findings. Third, in this study, the survey questionnaire was intended to be completed by one manager from each manufacturing company. While this technique is

frequently and commonly employed in the manufacturing literature, it has the potential to introduce informant bias. Future studies are recommended to employ a multiple-informant approach to mitigate possible informant bias.

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