Quality of Information Sharing, Agility, and Sustainability of Humanitarian Aid Supply Chains: An Empirical Investigation

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***Abstract*— This study aimed to explore the intermediary role of supply chain agility in the relationship between quality of information sharing and sustainability of the humanitarian supply chain. Questionnaire surveys were developed and administered to senior's managers and assistant executives of the Jordanian Army and Red Crescent. The findings of the data analysis showed that the quality of information sharing positively impacts humanitarian supply chain sustainability. Furthermore, agility in supply chains partially mediates the relationship between quality of information sharing and supply chain sustainability. This study contributes to the existing body of literature on humanitarian aid supply chains by developing a comprehensive framework illustrating the role of inherent mechanisms of agility in the relationship between information-sharing quality and integrating sustainable development objectives, derived from recipients, relief seekers, and stakeholder requirements.**

***Keywords*—** *Information-sharing quality, Supply chain sustainability, Humanitarian aid supply chain, Supply chain agility, triple bottom line.*

1. Introduction

In the field of logistics and supply chain management, the academic literature has clearly focused on for-profit organizations, while non-governmental organizations (NGOs) and non-profit organizations have attracted little attention. Recently, this trend has changed slightly and studies have been carried out on previously unexplored areas and sectors, such as relief and humanitarian organizations[31]. The main objective of the supply chain of humanitarian organizations is to ensure that relief supplies are distributed to recipients in the event of a humanitarian disaster [33], [43]. To this end, each partner of the supply chain should be convinced of the relevance of communication, collaboration [7], [36] ,and rapid disaster response with its supply chain network [19]. Therefore, there have been repeated calls to improve the response between and within relief supply chains and to facilitate the sharing of information in the delivery of aid [31], [36],[47].

Although the increased value of information exchange inspires organizations to communicate as much data as is feasible, the actual situation in the world is inconsistent, as facts is hidden, misleading, manipulated, or simply missing, thereby reducing the amount of necessary information required to make decisions [12], [36]. In addition, participants of the humanitarian supply chain are often reluctant to exchange information [31]. This is commonly observed among supply chains partners as a result of inflated information that somehow encourages donors to respond to disasters, and there is competition for donor and supplier access [32],[51]. Hence, it is imperative to examine the links between the quality factors of information sharing and performance of humanitarian operations.

The performance of humanitarian operations should provide inherent mechanisms for agility in terms of the dynamic sensing, dynamic speed, and dynamic flexibility of supply chains and their networks [4],[19],[20], while also integrating sustainable development objectives of all three dimensions, namely, economic, environmental, and social, inferred

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from recipients (beneficiaries and relief seekers) and stake holder requirements [45]. This is because most emergencies require an immediate response, and supplies are typically limited and funds are small, while performance metrics have proved to be crucial to achieving the objectives of humanitarian operations in terms of securing lives, mitigating human suffering, and ensuring patron aid (accountability) and economic stability [4], [43]. In this sense, agility can be regarded as a short-run enabler of a long-run sustainable development. Agility is more a concise technique for responding more quickly to customer requests [8], [19] ,and humanitarian crises [40] in the shortest time. Meanwhile, sustainability can be defined as a normative criterion against ideal ecological, economic, and social criteria for determining long-term success [21].

The concept of sustainability is strongly suggested for the commercial sector as a requirement for business in the 21st century [11]. There is also growing concern among humanitarian organizations about the long-term impact of the operation. In fact, sustainability is becoming crucial to maintain a competitive position (order winner) [33], [43]. Nevertheless, there is a paucity of empirical studies of the link between the short-run objectives of agility and the long-run impact of agility [16], [24], [43]. Hence, the primary research questions of this study are as follows. How can quality information-sharing factors influence agility and long-run sustainability of the humanitarian supply-chain?. As a short-term objective, how does agility influence long-term sustainability? How does the intermediary role of agility in the supply chain affect the association between quality of information sharing and sustainability?. This article considers that the answers to these research questions would provide conclusive evidence about whether the quality of information sharing promotes the short-term and long-term success of humanitarian operations.
The following section of this paper discusses the literature on the agility, sustainability, and quality of information sharing in the supply chains of humanitarian aid. Then, the study design is clarified, Complemented with analysis and results. The final section discusses the research findings, limitations of the work, and implications for future investigation.

2. Literature Review

2.1 Information-sharing Quality in Humanitarian Aid Supply Chains

The Global Logistics Research Team [23] has described information sharing in the supply chain as readiness to exchange essential technical, economic, operational, and strategic information. As such, the information disclosed between participants of the supply chain should be up-to-date, accurate, and exchanged in a relevant, timely, confidential, and credible manner [18]. Specifically, data is produced at each point of the supply chain and must be collected, used, and analyzed in a somewhat manner as to provide the right data that is relevant to the decision-making process, in an appropriate format, and economically relevant to the decision-makers concerned in a timely manner [17].
Information from the point of view of relief supply chains entails understanding the relationship between humanitarian aid and disaster-related data. A multiplicity of information and false information in the event of an emergency is a particular problem for supply chain relief [29]. Some of this misinformation may be deliberate, for example, when organizations or country's governing body release high projections of individuals impacted in a distress to inflate donor reaction; or, on the contrary, when governments hide data so as not to appear vulnerable. The sharing of information in the relief aid is of the highest priority, since it serves to help to save lives. Information is commonly distributed in the humanitarian field and is owned by various organizations [51]. Competition between humanitarian organizations is another reason for inhibiting or facilitating the sharing of information. Supply related to competition concerns access for donors and suppliers, that is, competition for limited resources and media attention [31]. Humanitarian organizations compete for media attention to gain access to a variety of financial and material resources. Therefore, they have incentive to inflate information and provide misinformation in the event of an emergency [32]. Consequently, the quality of information exchanged in the sense of humanitarian aid supply chains is considered to be the most crucial aspect in addressing the specific requests and demands of people seeking relief as well as improving response in humanitarian supply chains.

2.2 Agility in the supply chain of humanitarian aid

In the context of commercial supply-chain management, a new paradigm known as “agility” is a solution for preserving competitive edge and enabling cooperation to achieve mutually agreed objectives. Agility can be described as an organization’s capacity to adapt and respond to unforeseen or unexpected changes, which is critical to attaining and retaining a competitive gain [8], [19], [46]. According to [22] agility, among other factors, can influence the success of the entire supply chains in different ways. First, the

information flow may boost sales volumes when an unprecedented product is launched on the marketplace and an inaccessible market is established as a result of supply or other infrastructure restraints. Second, the enormous benefits obtained through information sharing provide a firm with the opportunity to react more meritoriously to buyer calls, requests, and preferences. As a result, supply chain agility enables a company to meet buyers' expectations, to follow orders, and to deliver a broader after-sales service. Consequently, information sharing creates more fruitful joint ventures between supply chain associates by accelerating collaboration and cooperation, which in turn contributes to the thresholds for supply chain agility.

Similarly, in view of the supply chain for humanitarian aid, succeeding agility is more applicable to firms in need of physically productive and efficient supply chain operating systems [44]. This indicates that agility practices are particularly applicable to the supply chains of NGOs and the humanitarian relief environment. Agility in the humanitarian supply chain is predicted to go beyond the flexibility of individual organizations, because it embodies the reactivity of the supply chain network as a whole. However, this feature adds additional emerging complexity to supply chains of humanitarian aid. In contrast to the commercial supply chain, in which survival and profit motives are paramount, actors in the disaster relief domain have intricate drivers and have significantly different delivery priorities [39]. The study of [44] stressed that adopting the conceptual principles of agility to the supply chains of humanitarian aid suggests the need to incorporate procedures all over the supply-chain and to ensure the quality of information shared between suppliers and their end-relief seekers, the beneficiaries of aid. This would include exchanging information about time, accuracy, completeness, honesty, and adequacy. This increased efficiency and reliability would significantly contribute to a reduction in costs, a significant reduction in bottlenecks, and increased timely support for recipients.

2.3 Humanitarian Supply Chain Sustainability

Scholars are now beginning to realize that supply chain operations are likely to be affected by external and internal influences that call for action in a manner that is socially accountable and economically and ecologically sound [20]. Addressing this trend could signal the start of the field of sustainable supply chain operations [11]. Sustainable supply chain management is characterized by the control of resources, data, and money flows, as well as collaboration between actors along the supply chain, whilst also integrating the sustainable development objectives (economic, environmental, and social) abstracted from buyer and the needs of interested parties [45]. These objectives (dimensions) are related entities following the 'triple bottom line' (TBL) model [39] or the TBL principle as one of the main drivers.

Only a few academics have contributed to the field of sustainability in the context of disasters, and the research remains in its early stages and is far from reaching maturity [33]. Sustainable humanitarian logistics seek to ensure that all human beings, particularly in the event of a disaster and crisis, have a standard of living that is sufficient for their and their families' health and well-being, together with food, clothes, housing, and healthcare, as well as the necessary social services by managing the effective, efficient forth and backward stream and storing of products or services and associated data throughout the entire supply chain, in a way that encounters today needs without undermining the capacity of future generations to cope using its own resources [30]. Although this description comprises a broad (but vague) perception of the sustainability aspirations of stakeholders, a study of [33] strengthened this concept by integrating key elements of sustainability dimensions. Also they [33] identified humanitarian supply chain sustainability as a network of firms involved in planning, overseeing, and organizing various processes and activities, including arranging, scheduling, ordering, processing, transporting, and distributing emergencies products and services from the place of origin to the place of supply, with the objective of mitigating the hardships and distress of people and societies impacted by catastrophes, while transparently and appropriately incorporating sustainability dimensions from the environmental, social, and economic aspects proceeding from the needs of the different interested parties. Similar to the mercantile supply chains, humanitarian supply chain sustainability can be measured using the sustainability definition discussed above [35], [33]. The present study uses these sustainability performance dimensions of the TBL model.

3. Development of Model and Hypotheses

The main premise of this article is that the quality of data communication in the humanitarian supply chains is required and should be encouraged in order to increase the speed and network integration of relief work in the humanitarian relief environment. This can be accomplished by maximizing the agility of the

supply chain, which is expected to lead to greater effectiveness and higher performance in all three pillars of sustainability (environmental, social, and economic). The research model is shown in Figure 1.

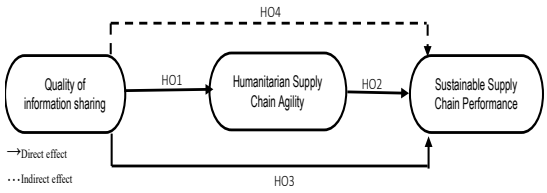

Figure 1. Research Model

3.1 Quality of Information Sharing and Humanitarian Supply Chain Agility

External partnering agility requires a huge amount of exchanging information between business partners to facilitate sensing and reacting (i.e., cooperative production and delivery) [6], [19], [49]. The information shared between partners should be up-to-date and accurate, and communicated in an appropriate, timely, confidential, and credible manner [7], [18]. According to [44] quality of exchanging information is a key factor for supply chain agility and is likely to be related to increased efficiency and effectiveness, which would contribute to a decrease in expenditure, a significant decrease in delays, and more timely support for recipients. Similarly, [19] argued that exchanging information is a key factor in the alignment of the supply chains, which is significantly related to improving agility in the case of relief supply chain networks. In the relief context, any attempt to hinder the accuracy, completeness, credibility, and adequacy of information exchanged between humanitarian organizations in conflict with donor conditions would halt funds for the aid and relief effort, and consequently, prevent material flows [28]. Resource flows, money flows, and information flows throughout the entire supply chain must be handled so as to achieve their optimal efficiency and effectiveness and to speed up collaboration and cooperation, which in turn would contribute to higher levels of supply chain agility [49]. In addition, the lack of a continuous and timely flow of information has a positive influence on the necessary, crucial response in the humanitarian supply chains. Given these previous findings in the literatures, the below hypotheses are suggested.

Hypothesis 1: Information-sharing quality positively and significantly affects humanitarian supply chain agility.

Hypothesis 1-1: Timely dissemination of information has a positive and significant influence on agility in humanitarian supply chain.

Hypothesis 1-2: Information accuracy has a positive and significant influence on agility in humanitarian supply chain.

Hypothesis 1-3: Completeness information has a positive and significant influence on agility in humanitarian supply chain.

Hypothesis 1-4: Credible information has a positive and significant influence on agility in humanitarian supply chain.

Hypothesis 1-5: Adequate information has a positive and significant influence on agility in humanitarian supply chain.

3.2 Quality of Information Sharing and Sustainable Supply Chain Performance

Information sharing between philanthropic aid and catastrophe relief in the supply chain has been regarded as a useful tool for addressing distorted information or misinformation, and for boosting the overall works of the supply chain [29],[31],[51]. Information-sharing quality comprises the 'accuracy, timeliness, adequacy, and credibility of the information' shared to enable effective supply chain management [5], [18], [37]. The quality of information sharing is much more than just sharing of data among participants within the supply chain. Rather, the information shared must be relevant and meaningful, and must be interpreted holistically by incorporating economic, social, and environmental perspectives. Furthermore, empirical evidence shows that sharing information about the rate of return is beneficial for an active risk response and leads to sustainable performance [4], [19],[26]. Hence, the extraction of substantial benefits from shared information is based on the quality and characteristics of that information. Similarly, a study of an NGO supply chain collaboration found that information sharing can contribute to knowledge creation, improved fundraising capability, economic efficiency, and organizational sustainability [1]. Based on the prior literatures, it can be argued that the sustainability of the humanitarian supply chain can be enhanced through a decent standard for quality information-exchange between upstream and downstream stakeholders, particularly together with the effective mediating role of agility in the supply chain, which has a strong influence on the triple-pronged goals of sustainable development, namely, economics, environmental, and social goals. Thus, we propose the below main and supporting hypotheses.

Hypothesis 2: Information-sharing quality positively and significantly affects humanitarian supply chain sustainability.

Hypothesis 2-1: Timely dissemination of information has a positive and significant influence on humanitarian supply chain sustainability.
Hypothesis 2-2: Information accuracy has a positive and significant influence on humanitarian supply chain sustainability.
Hypothesis 2-3: Completeness information has a positive and significant influence on humanitarian supply chain sustainability.
Hypothesis 2-4: Credible information has a positive and significant influence on humanitarian supply chain sustainability.
Hypothesis 2-5: Adequacy of information sharing has a positive and significant impact on humanitarian supply chain sustainability.

3.3 Humanitarian Supply Chain Agility and Sustainable Supply Chain

To clarify the link between agility and sustainability of relief supply chain, we argue that the capability for an agile response phase in which dynamic sensing, speed, flexibility, and integration have been identified as an appropriate "core" element involves working with each other as a supply chain to maintain that aid is beneficial, secure and reachable to those seeking relief. At the ecological and economic levels, agility drives prompt assistance to beneficiaries and more efficient use of resources, optimizes direct and indirect resources, and helps to ensure better aid work at a lower cost. Dubey and Gunaskaran [19] recently confirmed that agility, among other factors, including adaptability and alignment, has an affirmative and substantial influence on the sustainability of the humanitarian supply chains. Furthermore, the study of [3] highlighted that agility contributes to cost savings and economic growth, as well as to customer responses and public needs, and therefore, leads to economic sustainability. Social well-being is achieved by satisfying the needs of beneficiaries/relief seekers and finding value at the appropriate cost, in a proper condition, at the correct place, and at the exact time. In the humanitarian aid context, the primary promise of agility often leads to disaster recovery in practical terms if supply systems fail to act [10], which in turn brings sustainable social and environmental benefits. Thus, we formulate the following hypothesis.

Hypothesis 3: Agility of humanitarian aid supply chains has a positive and significant influence on humanitarian supply chain sustainability.

3.4 The Mediating Role

Information sharing, among other factors, is a prerequisite for fostering business value creation in the agile supply chains [27]. Exchange of information influences operational efficiency via the intermediary role of supply chain agility, which is also governed by situational factors and information system capabilities [6],[27],[48],[50]. This argument provides an important roadmap for organizations to incorporate information sharing and enhance supply chain agility. However, competition between humanitarian organizations may increase the amount of information that has been distorted and misinformation given in the case of an emergency. Therefore, the supply chain's rapid response to order information would be delayed and would actually influence the agility and flexibility of the supply chain [31]. As a result, the quality of information shared (in terms of timeliness, accuracy, completeness, honesty, and adequacy) in the setting of humanitarian supply chain is considered to be the most important factor for addressing the specific needs and demands of relief seekers as well as improving response in humanitarian supply chains, which in turn brings sustainable benefits. Specifically, agility is one of the principal bases of before - after-disaster humanitarian supply chain performance measures [2] ,[6],[20]. Similarly, sustainability can be characterized as a normative standard for measuring long-range success alongside the ideal ecological, economical, and social criterion [21]. However, agility is supplementary of a descriptive strategy for the short-range capability to respond more quickly to customer demands, requests [19], and emergencies in the humanitarian context [40]. Thus, it is the main feature of any organization with long-range sustainability objectives in dynamic structures with ever-changing settings. As such, an enterprise can be agile and unmaintainable, and cannot be sustainable in the absence of agility, as it'd be too vulnerable to short-range disruption due to exposure to change. Information-sharing quality is another factor linked to the sustainability and agility of the supply chain; it is often used so that relevant, timely, confidential, and credible information can be shared in an up-to-date and accurate manner. In this way, information-sharing quality can be realized as an aspect of humanitarian supply chain agility and agility as a short-range facilitator of long-standing sustainability. Thus, the below hypotheses are formulated.
Hypothesis 4: Humanitarian supply chain agility intermediates the link between information-sharing quality and sustainable supply chain objectives.
Hypothesis 4-1: Humanitarian supply chain agility intermediates the link between information accuracy and sustainable supply chain objectives.

Hypothesis 4-2: Humanitarian supply chain agility intermediates the link between information adequacy and sustainable supply chain objectives.
Hypothesis 4-3: Humanitarian supply chain agility intermediates the link between information completeness and sustainable supply chain objectives.
Hypothesis 4-4: Humanitarian supply chain agility intermediates the link between information credibility and sustainable supply chain objectives.
Hypothesis 4-5: Humanitarian supply chain agility intermediates the link between timely information and sustainable supply chain objectives.

4. Research Design

4.1 Measures

To develop a measuring instrument for this study, this study applied the following three techniques.

1. *Exhaustive literature study.* This was used in particular for the quality of information sharing, agility, and supply chain sustainability as shown in Table 1. Constructs were extracted or modified from the measures well-known in the literature to prevent scale proliferation. For the proposed theoretical model, this study used a multi-item scale of constructs to enhance reliability, decrease measurement errors, guarantee higher variability among people surveyed, and enhance validity [14].
2. *Expert opinion followed by pre-tests*. This study consulted 15 experts for pre-tests, including from the Jordanian Army, Jordan Red Crescent, and senior academics. The quality of information sharing included 15 items based on pre-testing results. The humanitarian supply chain agility measure remained as it stood, with 12 items covering four dimensions: dynamic sensing, dynamic speed, dynamic flexibility, and network integration. Finally, the sustainability of the supply chain included a nine-item measure encompassing three pillars: economic, social, and ecological performance. The survey questionnaire was divided into two sections, the first consisting of the organizational profile of the respondent firms and the second related to the sustainability, agility, and quality of information sharing in the humanitarian supply chain.
3. *Pilot study to verify the construct's reliability and validity.* A pilot study was conducted to identify unclear items or those that might not be suitable or that might discriminate between participants. Initially, three main factors were checked during the questionnaire piloting: analysis of the item, internal consistency, and validity of the face or content.

Table 1. Constructs and items of instrument.

Constructs	Items References	References
The quality of information sharing	-Timely -Accuracy -Completeness -Credibility -Adequacy	[9], [18], [26], [41].
Humanitarian supply chain agility	-Dynamic sensing -Dynamic speed -Dynamic flexibility - Network integration	[46], [19], [20], [15], [47].
Sustainable Supply chain performance	-Social Performance -Economic Performance -Environmental Performance	[8],[46],[33], [35], [42], [3].

4.2 Data Collection

The survey questionnaire was directed to the Jordanian Army and Jordan Red Crescent, including seniors managers, assistant executives, logistics and transportation officers, NGOs, and donors. To allow participants to respond comfortably, the survey questionnaire was bilingual (Arabic and English) and was intended to include both positive and negative answers to prevent bias. The technique of personal administration was used and the respondents were guaranteed that their anonymity would be preserved. The questionnaire was sent to potential participants by email, followed up by calls. Initially, 188 usable responses were received, and after follow-up e-mail and phone calls, another 61 usable responses were received. Finally, measures representing the study variables were recorded using a 5-point Likert scale (1=strongly disagree to 5=strongly agree).

5. Data Analysis

5.1 Assessment of Validity and Reliability

SmartPLS 3.0 software was used to evaluate the validity and reliability of the measurement model. Three measures were used to assess the reliability of the instrument: Cronbach's alpha (α), composite reliability (CR), and average extracted variance (AVE). Following the guidelines of [25], we confirmed the reliability of the scale using Cronbach's α and CR values, as shown in Table 2 and Figure 2. All Cronbach's α and CR values for each of the three constructs (information-sharing quality, humanitarian supply chain agility, and sustainable supply chain performance) ranged from 0.708 to 0.933, overcoming

the proposed threshold of 0.70 for Cronbach's α values and 0.60 for CR values [13],[25], which demonstrates adequate internal consistency. Furthermore, convergent validity was evaluated using the AVE, which denotes the degree of agreement between various items evaluating the same notion. Each construct had an AVE value of more than 0.50, suggesting very good convergent validity, and therefore, both tests showed adequate validity.

Discriminant validity (DV) was tested to confirm the results. DV was performed to ensure that each concept of each latent construct differed from that of the other constructs. DV involves the square root of AVE for each latent variable surpassing the absolute value of the correlation between that variable and other variables [20]. Table 2 shows the construct inter-correlations and the shared variance among the latent constructs and their indicators. The diagonal components in Table 3 are the square root and construct correlations of the AVE. The results imply that the square root of each AVE value are larger than the off-diagonal components. As a result, strong support for discriminant validity is demonstrated.

Table 2. The standardized loadings, Cronbach's alpha, Composite reliability and AVE.

Construct	Measurement item	Loadings	Cornbrash's Alpha	CR	AVE
Timely	TI1	0.868	0.775	0.868	0.688
	TI 2	0.781			
	TI 3	0.837			
Accuracy	AC1	0.821	0.735	0.847	0.648
	AC2	0.790			
	AC3	0.803			
Completeness	CO1	0.888	0.83	0.897	0.743
	CO2	0.851			
	CO3	0.848			
Credibility	CD1	0.777	0.708	0.837	0.631
	CD2	0.848			
	CD3	0.756			
Adequacy	AD1	0.816	0.727	0.845	0.644
	AD2	0.784			
	AD3	0.807			
Supply Chain Agility	Dynamic sensing	0.915	0.747	0.933	0.777
	Dynamic speed	0.901			
	Dynamic flexibility	0.829			
	Network integration	0.879			
Humanitarian Supply Chain Sustainability	Social Performance	0.758	0.904	0.807	0.583
	Economic Performance	0.689			
	Environmental Performance	0.837			

Note. CR= composite reliability; AVE=average variance extracted, TI= timely, AC= Accuracy, CO= Completeness, CD= Credibility, AD= Adequacy.

Table 3. Discriminate Validity

Constructs	1	2	3	4	5	6	7
(1) Agility	**0.764**						
(2) Accuracy	0.556	**0.805**					
(3) Adequacy	0.667	0.414	**0.803**				
(4) Completeness	0.498	0.73	0.524	**0.862**			
(5) Credibility	0.511	0.446	0.522	0.44	**0.795**		
(6) Sustainability	0.812	0.572	0.545	0.521	0.456	**0.882**	
(7) Timely	0.466	0.616	0.437	0.564	0.374	0.373	**0.829**

5.2 Structural Model

The structural model assessment was performed using SmartPLS to confirm the hypothesized relationship between the constructs. The significance of path coefficients for each endogenous latent variable was included in the structural model to signify the power of relationships between (R2) values [13], [25]. Besides, the p-value ($p< 0.05$) was utilized as a statistical conclusion measure and t-values were supported if they were higher than 1.96. The effect size of the f-test was utilized to define the contribution of an exogenous variable to an endogenous latent variable. Following the instructions of [25], an (f^2) value of $0.02 < 0.15$ for an exogenous construct indicates a small effect size. An (f^2) value between 0.15 and 0.35 yields a medium-effect size, and an f^2 value of 0.35 or more produces a large-effect size. A bootstrapping re-sampling procedure was used to test indirect and mediating effect models and to determine the consequence level of the defined paths within the structural model.

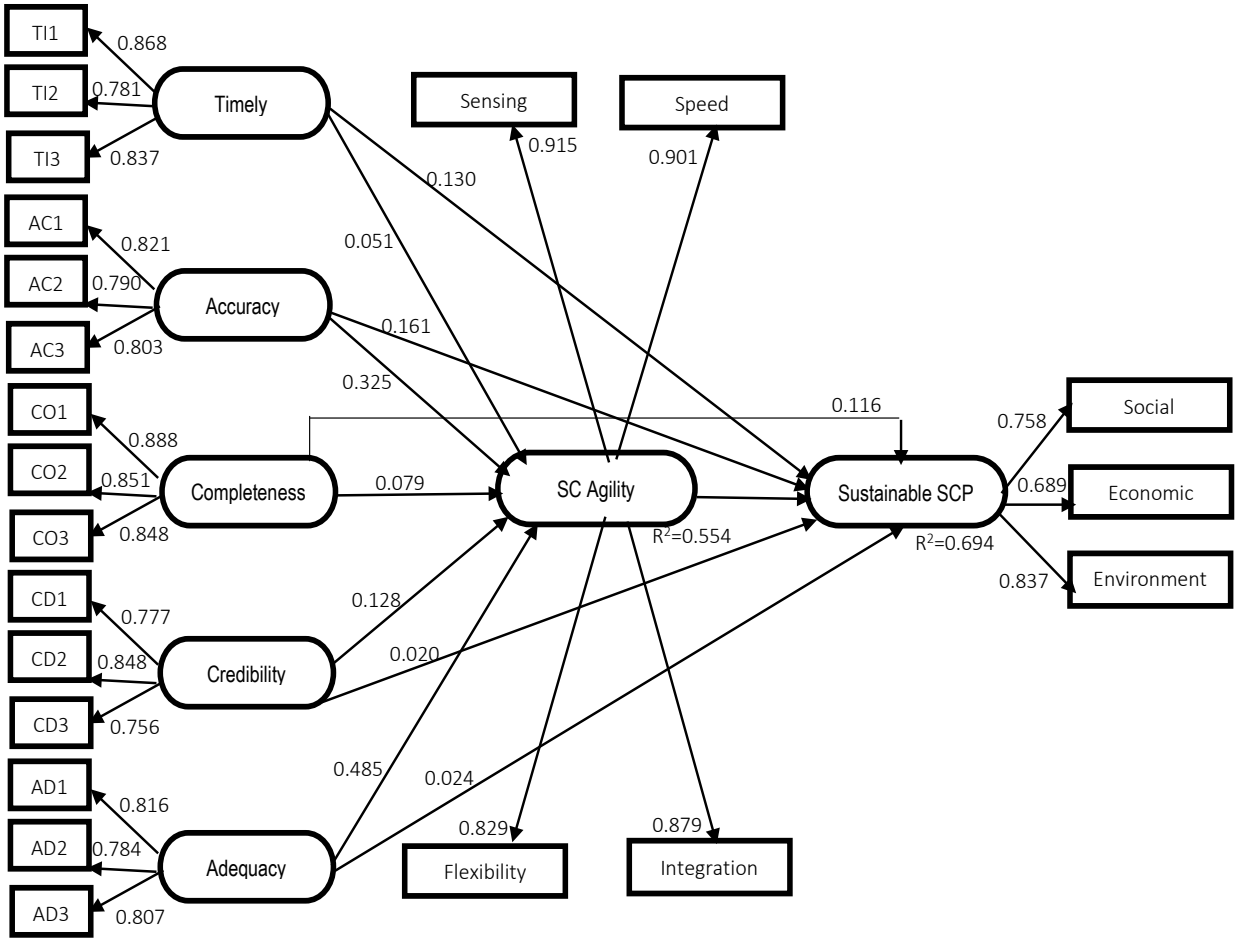

Figure 2. Measurement and Structural Model Results

6. Results

6.1 Inner Model Testing

Considering the R-square value, which is a goodness-of-fit test model, the structural model test was carried out. From Table 4, the influence model of information-sharing quality on the agility of the humanitarian supply chain yields an R-square value of 0.554, which can be interpreted as follows: 55.4% of the construction variability in agility can be explained by the quality of information sharing. The impact of humanitarian supply chain agility on sustainable supply chain performance gives an R-square value of 0.694, which can be interpreted as the variability of the sustainable performance construction, and can be explained as agility variability of 69.4%.

Table 4. Direct relationships within the structural model.

Path Shape	Coefficient (β)	Mean	Standard Deviation	T Statistics	P Values	R^2	F^2
Timely → Agility	0.051	0.053	0.051	1.992	0.046**	0.554	0.013
Accuracy → Agility	0.325	0.324	0.063	5.196	0.000***		0.093
Completeness → Agility	0.079	0.081	0.071	1.112	0.266		0.016
Credibility → Agility	0.128	0.127	0.059	2.180	0.029**		0.024
Adequacy → Agility	0.485	0.49	0.059	8.240	0.000***		0.317
Agility → Sustainability	0.731	0.726	0.051	14.26	0.000***	0.694	0.778
Timely → Sustainability	0.130	0.131	0.047	2.761	0.006**	0.694	0.031
Accuracy → Sustainability	0.161	0.164	0.070	2.286	0.022**		0.093
Completeness → Sustainability	0.116	0.116	0.062	1.984	0.047**		0.017
Credibility → Sustainability	0.020	0.023	0.042	2.487	0.013**		0.001
Adequacy → Sustainability	0.024	0.021	0.049	2.481	0.013**		0.001

****p>0.001; **p>0.05*

6.2 Direct Relationships

The results of the analysis of the structural equation model are shown in Table 4 and Figure 2. The supported hypotheses implied a significant relationship with T-statistics exceeding 1.96 and $p<0.005$. In particular, the path coefficients of all information-sharing quality constructs except the completeness construct had significant positive effects on humanitarian supply chain agility (β for timeliness = 0.051, β for accuracy = 0.325, β for credibility = 0.128; and β for adequacy = 0.485 at $p < 0.05$ level of significance and t-value > 1.96). The construct of completeness in quality of information sharing was not statistically significant for agility (t-value < 1.96 and $p > 0.05$). The direct effect of quality of information sharing and humanitarian supply chain agility (β for agility = 0.731; β for timeliness = 0.130; β for accuracy = 0.161; β for completeness = 0.116; β for credibility = 0.020; and β for adequacy = 0.024 at the $p < 0.05$ level of significance and t-value > 1.96) had significant positive effects on the endogenous construct of supply chain sustainability. Consequently, the main and supporting hypotheses (Hypotheses 1, 1-1–1-5 except 1-3, 2, 2-1–2-5, and 3) were endorsed.

6.3 Indirect Relationships

A bootstrap re-sampling technique with 5000 re-samples was executed to test the mediation effects. From Table 5, the results showed a positive and significant indirect effect of accuracy on sustainability mediated by the agility of the supply chain (β = 0.237 and t-value = 5.100 $p<0.05$). Similarly, the indirect effect of adequacy on sustainability as mediated by supply chain agility was positive and significant (β = 0.354 and t-value = 6.353, $p<0.05$). Completeness accounted for a negative and significant indirect effect on sustainability mediated by the agility of the supply chain (β = -0.058 and t-value = 2.090 $p<0.05$). Finally, there was an indirect effect of credibility and timeliness on sustainability as mediated by supply chain agility (β = 0.094, 0.037; and t-value= 2.246, 0.037; $p<0.001$). Thus, Ho4, Ho4-1 to Ho4-5 were supported.

In addition, this study used variance accounted for (VAF) analysis to assess the strength of the mediation or estimation of the significance and size of the indirect effects in relation to the total effect. The VAF index determines the extent to which the variance of the dependent variable is explained indirectly through the mediator variables. VAF values below 20% show a very strong direct effect and no mediation; values between 20% and 80% show that partial mediation exists; while full mediation can be verified when VAF reaches more than 80% [25],[38].

As shown in Table 5, the path coefficients of all quality of information sharing constructs (except the adequacy construct) on sustainability are partially mediated by agility, as the VAF values are within the 20–80% range. Meanwhile, the adequacy construct reaches VAF = 93.7%, which means that the indirect agility effect fully mediates the relationship between adequacy and sustainability, since the VAF value is far greater than 80%.

Table 5. Indirect effect

Path Shape	Path Coefficient	Standard Deviation	T Statistics	P Value	Support	VAF*
Accuracy → Agility → Sustainability	0.237	0.047	5.100	0.000***	Yes	0.596
Adequacy → Agility → Sustainability	0.354	0.056	6.353	0.000***	Yes	0.937
Completeness → Agility → Sustainability	-0.058	0.053	2.090	0.037**	Yes	0.332
Credibility → Agility → Sustainability	0.094	0.041	2.292	0.022**	Yes	0.756
Timely → Agility → Sustainability	0.037	0.038	1.988	0.047**	Yes	0.223

***p>0.001; **p>0.05; *VAF = (indirect effect / total effect) × 100

7. Discussion and Conclusion

The rationale for this study stems from two issues. First, the quality of information sharing in the humanitarian supply chain is playing a growing role in response to catastrophe and must possess characteristics to recover its original configuration. In line with this, scholars and practitioners have called for high-quality sharing of information between public and private companies (logistics and other firms) to increase the speed and efficiency of relief work in the humanitarian relief environment. Second, since the incidence of natural disasters has grown considerably in recent years, despite cumulative contributions to the field, there is a growing need for sustainability of humanitarian supply chains, which serves as an opportunity for forward-thinking countries and a threat to countries that fail to act. The primary objective of this study was to determine whether the interventions of supply chain agility leverage potential associations between quality of information sharing and sustainable supply chain performance.

First, this study asked how the quality of information sharing is related to the agility and sustainability of the humanitarian supply chain. In line with previous studies, we found strong support for the hypothesis that the quality of information sharing factors (in terms of timeliness, accuracy, credibility, and adequacy) may promote the agility of the humanitarian supply chain [19],[44],[49], while the factor of completeness undermines agility. A possible reason is that there is much less cooperation between cross-functional disaster management teams, and many disaster relief agencies compete with each other to prove their supremacy in obtaining public support. This leads to incomplete exchange of information among participants, and may even lead to misappropriation of the facts. Another possible reason, as suggested by [34], is that the completeness of information during emergencies requires extensive documentation and advanced information technology, while the available resources and budgets at the time are usually limited and agility practices rely heavily on rapid response to disasters and emergencies. It must also be recognized that information sharing contributes effectively to supply chain sustainability from different quality factors to ecological, economic, and social requirements for long-term success. This finding is consistent with [1]. A logical explanation is that sharing information strongly helps to reduce uncertainty, while increasing supply uncertainty undermines long-term success.

The second research question asked how agility as a short-term objective influences long-term sustainability. The results show that agility in humanitarian aid supply chains has positive direct effects on supply chain sustainability. This finding, which is in line with those of [19], among others, is unsurprising, as the achievement of short-term goals in terms of dynamic sensing, dynamic speed, and dynamic disaster response efficiency with its single-level supply chain network acts as a means to achieve long-term sustainability and ends at the next step.

The third general research question asked how the intermediary role of supply chain agility affects the association between quality of information sharing and sustainability. This proposed mediating role was confirmed. Notwithstanding partial mediating effects, these mediating effects showcase that agility in humanitarian supply chain is an outcome of quality of information sharing on the one hand, and is an antecedent of sustainable supply chain performance on the other hand. Nonetheless, because all quality of information sharing constructs (except the adequacy construct) have a partial mediating effect, this implies that they do not fully explain the association between quality of information sharing and sustainability. In fact, it must be acknowledged that other variables are likely to play a role. For instance, the study of [27] found that an integrator's opportunistic behavior and integration capabilities of the logistics service supply chain for sustainable performance fully explain the

relationship. However, this might not be the case in this study, as [27] studied functional logistics service providers in a commercial sector with a stable environment rather than humanitarian emergencies, which could explain the different results.

Further research was carried out to evaluate whether information-sharing qualities and sustainability are linked to employees' nationality, age group, and educational level (although this was not hypothesized). No significant differences were identified and therefore, the results are not presented in the paper.

In conclusion, this research contributes to the body of literature first, by creating a more complex and comprehensive model that explores the direct relationship between quality of information sharing and sustainable supply chain performance and the indirect mechanisms through which humanitarian supply chain agility mediates the relationship; second, by providing empirical support for the hypothesized model; and third, in order to bridge the gap in the literature of such a study in a non-Western context, by applying the proposed model in the context of a developing country, Jordan.

7.1 Managerial Implications

More focus is being placed on research on the quality of information exchanged between members of humanitarian aid supply chain and the implications thereof. In fact, the findings of this study indicate that the quality of information sharing is crucial not only for the prevention of distorted information and misinformation provided in the event of a disaster, but also in shaping the ability to respond faster to relief seekers and long-term success against ideal environmental, economic, and social considerations. This fact, on its own, is extremely attractive not only to academics and scholars, but also to practitioners.

Specifically, the supported hypotheses provide practical guidance for NGO, relief, and humanitarian managers to enhance sharing of information, inherent agility mechanisms, and integration of the three-dimensional sustainable development objectives, namely, economic, environmental, and social. This study reinforces the notion that the quality of information sharing creates a sense of openness for cooperative communication between supply chain partners. Quality of information sharing decreases the negative impact of competition on access to donors and suppliers as well as distorted information, enabling partners to increase collaboration and cooperation, which in turn leads to higher levels of supply chain agility and sustainability.

7.2 Limitations and Future Research

This investigation has two limitations. First, this research discussed only the influence of the humanitarian supply chain agility (i.e., dynamic sensing, dynamic speed, dynamic flexibility, and network integration) on long-term sustainability. Other impactful relationships may exist among actors along the supply chain. Second, the survey analysis focused on the capital of Jordan. Future studies could expand the sample size to examine users from other countries with a view to obtaining more accurate statistical analysis results and to explore whether there are cultural differences.

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