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# A Meta-analysis of a Resilient and Sustainable Supply Chain During 2011-2020

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## Abstract

Nowadays, Supply chains can be explored through two concepts of resilience and sustainability. This paper attempted to conduct a meta-analysis of a resilient and sustainable supply chain while proposing a new conceptual model.

Meta-analysis is a type of quantitative meta-study conducted only on the results of previous studies. With a focus on a decade of studies from 2011 to February 2020, this paper intended to explore the literature on resilient-sustainable supply chains. To that end, a total of 39 relevant papers were selected and reviewed. The statistical population comprised 15 papers dealing with both resilience and sustainability. Moreover, the dimensions and indicators of analyses were identified based on the opinions of 10 supply chain experts and the Delphi method.

Based on the collected data, a new conceptual model was presented with initial information and conceptual models not reflected in previous independent research. In the newly proposed conceptual model, the supply chain resilience and sustainability were contributed by several components including structure (34%), resources (31%), capabilities (13%), innovation and production (7%), and transportation and environmental assessment (4%). Furthermore, information sharing plays a key role in facilitation and integration of supply chain resilience and sustainability. Since findings indicate the growing importance of global energy consumption and a large research gap in this area, it is highly recommended that future studies focus on supply chain sustainability and resilience in the energy sector. In this research, for the first time, the meta-analysis approach was applied in a resilient and sustainable supply chain, and based on the received information, a conceptual model was proposed that the initial information and conceptual models in previous independent studies did not show.

**Keywords: Meta-analysis, Supply chain, Resilience, Sustainability.**

## 1- Introduction

Nowadays, competition between companies has been replaced by competition between supply chains. In other words, there is a network of companies converting raw materials into finished products and delivering them to end consumers [1]. Events leading to stoppage in the flow of materials, even occurring in a remote area, can interfere the production process on a large scale. Such stoppages may be distributed across the supply chain, leaving extremely adverse effects. In a worst-case scenario, many companies fail to retain their productivity levels when a disruption occurs. As a result, disrupted companies lose competitiveness [2]. In other words, if supply chain activities fail to handle unforeseen disruptions appropriately, there will be potentially harmful consequences. This eventually escalates the risk of business continuity, causing huge amounts of financial loss [3]. Supply chain resilience can specify the capacity of deflecting disruptions and retaining the basic, structural supply chain tasks in the face of stoppages [4, 5]. Although a limited number of conceptual and empirical studies have been carried out on sustainable supply chains, there has been a rapidly growing trend of quantitative analytical studies and models concerning SCM [6-8]. However, supply chain sustainability is a fairly recent and highly influential topic widely discussed by SCM researchers [9]. Sustainable development has become a major jargon in the business terminology. Influenced by sustainability practices through the integration of economic, environmental and social goals, professions extensively gain a competitive edge when sustainable supply chains are projected. Most organizations pay attention to the strategic importance of sustainable investments. In this environment, the development and availability of analytical models and decision support tools can help organizations make more effective, informed decisions [10]. In response, academic research has been developed on the design and management of sustainable supply chains over the past two decades [6-8, 11]. Most efforts in sustainable supply chain have been orchestrated to mitigate the supply chain's burden of environmental responsibility in measuring greenhouse gas emissions and consumption of resources [12]. In terms of social sustainability, the focus has mostly been shifted on damages to human community health [13]. Any success in the modern business environment requires continuous supply chain improvement. To this end, it is critical to evaluate supply chains and extract the performance indicators [14]. An evaluation involving the dimensions of sustainability is different from an evaluation of traditional business-oriented performance. When dimensions of sustainability are considered, the scope of evaluation should be expanded. In addition to its economic dimension, sustainable development covers environmental and social dimensions [15]. Despite the growing efforts in the design and management of sustainable supply chain, there is little known about the effects of sustainability dimensions on resilient supply chains. In a specific environment affected by frequent inevitable stoppages, sustainable supply chain management requires a sustainable modeling and analysis adaptable to that dynamic complexity. Static sustainability analysis is simple because the sustainable economic and non-economic performances of a supply chain can be influenced by interruptive events such as supply stoppage [10]. Given the current loopholes, this study attempted to conduct a meta-analysis of a resilient and sustainable supply chain, while exploring the dimensions and indicators of supply chain resilience and sustainability.

## 2- Theoretical background and literature review

### 2-1- Measuring and modeling of resilient supply chains

The recent global financial crises and the frequent rise of human and natural catastrophes demonstrate why organizations need to deal with major supply chain disruptions [2, 16, 17]. Today, supply chains require high flexibility and agility so as to quickly and regularly respond to fluctuations in demand, supply, current exchange rates and lag time. Such stoppages are usually managed at the technical design level through building flexibility in supply chains [18]. As a well-known technique for resilient supply chain, *expected value* has been extensively adopted in making accurate mathematical decisions on investment and prioritization of resilience structure options by assigning weights to future events and calculating the expected values of various disruptive scenarios. Snyder and Daskin were among the early proponents of expected value approach [19]. Aryanezhad et al. and Chen et al. expanded this model for decision-making on joint inventory under the assumption of equal independent probability for interruption and occurrence [20, 21]. The unequal interruption possibilities have been also studied by other scholars [22-26]. Supply chain models have been explored for scenarios with dependent interruption probabilities [27-29].

Certainly, Value at Risk (VAR) and Conditional Value at Risk (CVAR) have been two popular criteria for resilient supply chains. Sawik proposed the portfolio methods for selection of suppliers alongside the risks of supply chain stoppages, VAR, and CVAR [30]. Sawik upgraded this approach to combine the selection and protection of suppliers and value allocation order [31]. The protective decisions included selection of suppliers, protection against stoppages and pre-deployed emergency inventory allocation for protected suppliers so as to maintain continuous supply when stoppages occur. Adopting a similar method, Sawik developed random mixed-integer planning models in order to integrate the selected suppliers and schedule customer orders under the threat of disruption [32-35]. Moreover, CVAR was adopted by Madadi et al. to measure the risks of disruption in the design of pharmaceutical supply chains [36]. Medal et al. experimented the integration of equipment location and difficult decisions in an attempt to minimize the maximum distance between the demand point and the closest equipment location at stoppages [37]. A multi-objective optimization approach was proposed by Hernandez et al. seeking to balance the total displaced weight distance before and after stoppages [38]. Without any need to remove potentially damaged equipment, the proposed approach allows a decision-maker to understand the effects of opened equipment on robust systems.

Apart from the above studies generally intending to protect the network against stoppages, there have been a few efforts focusing on the network capability to discover previous malicious events. Pant et al. proposed a modeling paradigm for system resilience as a function of vulnerability (early undesired impact of stoppage) and recovery capability (system recovery speed) [39]. This study presented several accidental resilience criteria including the time to repair the entire system, time to service resilience of the entire system, and time to resilience percentage. Baroud et al. studied the useful application of these criteria in the design of inland waterway network [40]. The previous studies by Baroud et al. introduced a randomized approach to calculate three criteria of resilience cost namely cost of service, cost of network repair and cost of dependent effects [41]. Similar authors also presented two approaches to measure the importance of resilient network components as a function of accidental vulnerability and recovery capability [42]. Furthermore, an optimization method was developed to determine a particular group of disruptive links to be recovered for resilience improvement. In this domain, Luzada et al. proposed a new model to accelerate the recovery time after stoppages and protecting a type of installations network failing under the worst-case scenario [43].

### 2-2- Measuring and modeling of sustainable supply chains

Numerous attempts have been made to model the environmental and green areas of sustainable supply chain, involving disruptions in sustainable environmental and economic calculations during the design and management of sustainable supply chain [44]. Minimization of greenhouse gas emissions has so far been the most desirable environmental goal [45]. The efforts made to model a green supply chain expanded in six directions. The optimal models for strategic supply chain design sought to balance the supply chain cost and $CO_2$ emissions [46-49], Tactical and operational design tools for the emission-cost balance in supply chains [12, 50, 51], Design and planning of closed-loop supply chains with a concentration on emission-cost of forward and reverse networks [52-54], Integration of life-cycle evaluation practices for assessment of environmental effects left by a sustainable supply chain [55, 56], Development and adoption of multiple performance criteria (beyond greenhouse gas emissions) for the management and design of green supply chains [12, 57-59] and introducing and reviewing environmental policy tools for optimization and design of supply chain planning [51, 60]. Apart from studies on the management and design of green supply chains, there have only been few attempts made to model the combined performance criteria in three dimensions of sustainability. In fact, there is no consensus on the measurement and reporting of supply chain social sustainability [61], which is a primary explanation for insufficient research in this area. Pishvayee et al. employed a number of jobs created, use of hazardous materials and job conditions as social criteria involved in the model designed for sustainable supply chain [62]. You et al. provided a multi-objective model to design a supply chain for cellulosic ethanol based on supply chain costs [63]. Pishvayee et al. presented a multi-objective probabilistic model to design a sustainable supply chain network through the 2008 guideline (Goedkoop et al.). estimated the environmental impacts of supply chain and GSLCAP (Benoıt and Mazijn). evaluated the social impacts of supply chain in three areas of job opportunities, customer/worker health risks, and local development [64-66]. Similarly, Zhang et al. conducted several studies on optimal design and cost planning in supply chains, greenhouse gas emissions, lag time, and social and environmental performance criteria [67]. Boukherroub et al. studied supply chain planning problems from the perspective of employee distance to industrial sites and job stability as criteria for social performance [13]. As evident in these studies, the selection of social and environmental criteria combined in supply chain models is a special technical problem. A comprehensive list of such actions can be obtained from previous studies [68]. Other instances of acceptable criteria include environmental-compatible indices 99 (Goedkoop et al.), social performance standards and SA8000 guidelines (SAI, 2008) and GSLCAP (Benoıt and Mazijn) [65, 66, 69].

**2-3- Resilient and sustainable supply chain modeling**

The relevant literature suggests that sustainability and resilience have been explored independently [70, 71]. By the same token, the efforts made to model supply chains did not explicitly link the dimensions of resilience and sustainability. In fact, there are scenarios where the dimensions and effects of sustainability in supply chain capacity are inconsistent with unforeseen stoppages. For instance, the majority of sustainability capabilities serve to enhance efficiency in utilization of resources and mitigation of redundant protections (similar to inventory points and fewer storage areas across the supply chain). Although such practices may be environmentally consistent and economically viable, supply chains may be more vulnerable to stoppages due to limited accessibility to safety inventory to cope with variations in supply and demand [72]. Flint et al. argued that resilience required an environmental assessment including internal and external evaluations in an attempt to discover capacities for innovation. They defined resilience as a tendency to change and innovate, highlighting the role of culture, history and market compatibility. Finally, they provided a new conceptual model, believing that sustainability could be achieved through resilience [73]. Carvalho et al. presented a conceptual model based on four graphs indicating that synergy between lean, agile, resilient and green paradigms in a supply chain is correlated with the frequency of information and integration level. Divergence in a supply chain occurs due to other parameters such as capacity surplus, inventory level, and refilling process [74]. Mourinho et al. proposed a supply chain model construction based on several factors including inventory level, number of suppliers and production rate through simulation software and promotion through analysis of critical outcomes and strengths in the supply chain. Moreover, they argued that supply chain sustainability could be achieved through the functional tasks of resilience [75]. Hank and Krome presented a conceptual model while demonstrating the complex relationships between risk, resilience, and sustainability in the supply chain. On the sustainable development background, it is crucial to adopt a new paradigm in SCM planning. The design elements for sustainable supply chain include system capabilities, system structure, and system resources. They further argued that innovation in management tools should be less dependent on ecological efficiency and more dependent on system resilience. The concept of resilience involves a tremendous potential for development, indicating the importance of sustainability in supply chains [76]. By an integrated methodology framework of collaborative interactive activities, system value chain analysis, process analysis and adoption of modern knowledge management, Malindretos and Binioris developed the understanding and utilization of an operational research and development framework to enhance collaboration, strengthen capacities and adopt a re-engineering strategy to support resilience and sustainability [77]. In their research, Hawker and Edmonds showed that sustainability challenges the basic assumption of performance analysis seeking maximization of profits, not to mention that efficiency may serve as a trap for lower resilience in markets facing sudden changes. Hence, it is vital to deal with both efficiency and resilience in order to curtail the fragility of supply chain networks [78]. With an innovative approach in a case study, Azevedo et al. provided an integrated composite index known as lean, agile, resilient, and green (LARG) to evaluate the supply chain behavior in the automotive industry [79]. Edgeman and Wu emphasized that strength, resilience, and sustainability of transcendental firms are crucial, desirable and complementary to various stakeholders. They identified several factors in SEER2, including intelligent information and data analysis, operational skills and supply chain, innovation, social and public ecology, and organizational ecology, while arguing that SEER2 is an outcome of strategic and tactical integration [80]. In their research, Papadopoulos et al. tested a theoretical framework, finding out that rapid trust, information sharing, and public-private partnerships are key empowerment factors for resilience in supply chain networks. They proposed a large-data analysis for a resilient supply chain framework capable of sustainability [81]. Fahimnia and Jabarzadeh investigated the relationship between resilience and sustainability at the design level of supply chains. Providing a multi-objective optimal model developing a sustainability performance scoring method and probabilistic fuzzy ideal planning approach, They managed to design a sustainable, resilient supply chain through dynamic sustainable performance analysis. This approach could progress from static resilient supply chain toward dynamic analysis to deal with unpredictable disruptions in the supply chain [10]. Golicic et al. argued that resilience is necessary for sustainability. Their research findings stressed the fact that innovation, resources and supply chain relations facilitate resilience in the supply chain [82]. In an analytical study on the distribution of disruptions in the supply chain with regard to sustainability factors, Ivanov examined the interactions of resilience and sustainable supply chain. For that purpose, they designed a resilient supply chain structure given the mitigation of ripple effects and growth of sustainability. In his research, Ivanov simulated three hypotheses, thereby to identify factors increasing and decreasing sustainability in the supply chain [83]. Zahiri et al. developed a linear multi-objective mixed-integer integrated resilient-sustainable planning model to design a supply chain network under conditions of uncertainty. In their research, Zahiri et al. developed new benchmarks and imported them in the model for resilience and sustainability. The new model integrated strategic and tactical decisions [84]. In another research, Zamanian et al. presented a multi-objective mathematical modeling of the oil and natural gas supply chain in Iran, that dimensions of resilience such as the service level and penalty per underutilized capacity added to sustainability dimensions of their previous research (Zamanian et al.) including social costs of greenhouse gas emissions, economic costs and total revenue earned in the consumption nodes at all levels and components of the natural gas supply chain, and analyzed the proposed new model by the Improved Augmented ε-Constraint algorithm [46, 85].

## 3- Methodology

As research projects grow in various fields of science and the scientific community faces an explosion of information, researchers have to admit how difficult it is to identify and understand all dimensions of a field and stay completely updated. Therefore, there has been a growing trend in meta-analysis, where the key results of studies on a particular subject matter are systematically combined and examined. Meta-study provides a technique to analyze, combine and conduct a pathological examination of previous studies. It involves a profound investigation of relevant studies conducted in a particular area [86]. Moreover, meta-study includes meta-analysis, meta-combination, meta-method and meta-theory according to figure 1. [87].

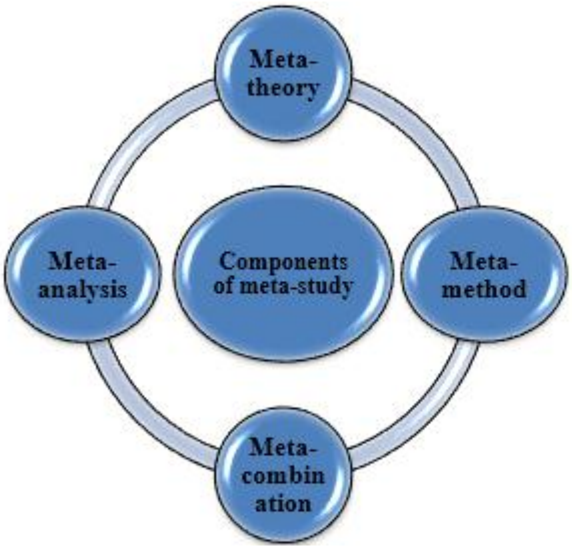


**Figure 1- Components of meta-study**

### 3-1- Meta-analysis

Adopted frequently over the last few years, meta-analysis refers to a type of quantitative meta-study conducted only on the results of previous studies [86]. Meta-analysis can be considered a systematic review of quantitative studies based on statistical and mathematical principles [88]. The unit of analysis in meta-analysis is the relevant studies on a particular subject matter. This approach leads to the identification of scientific gaps and aggregation of previous studies. According to figure 2. there are seven conventional steps taken in a meta-analysis. In the first step, the subject matter is selected and the research variables are defined. The most important task at this step is to determine the research scope and objectives. In the second stage, previous studies are identified, compiled and summarized according to the research objective. Finally, a number of valid sources are selected with regard to the research objective. The third step involves filtering the contents of sources leading to the categorization, evaluation, and recreation of findings. Moreover, the input studies are converted into a set of classified information, enabling the review and extraction of results. In the fourth step, the findings are categorized based on statistical methods, comparative overview of methodologies, identification of diversity in hypothesis testing and comparison of results. The fifth step defines and combines the results, while the sixth step matches and compiles the results to facilitate reporting. Therefore, the seventh step involves generation of reports and interpretation of results [89]. This paper attempted to conduct a meta-analysis of resilient and sustainable supply chain while presenting a new conceptual model through dimensions and indicators creating resilience and sustainability in supply chains. Such meta-analysis has proved desirable since there are no transparent guidelines to reflect the resilient and sustainable supply chain conditions.

### 3-2- Delphi

Delphi is a systematic research technique to extract the opinions of a group of experts about a subject or a question [90]. The main components of Delphi method include iteration, questionnaire, panel of experts, controlled feedback, anonymity, analysis of results, consensus, time, and coordinator team [91]. In each phase of this research, the expert opinions serve as a complementary strategy to guarantee the research quality and value. This research involved the opinions of 10 experts specializing in supply chain. Moreover, several key dimensions and indicators were identified through the Delphi technique for analysis.


**Figure 2- Steps of meta -analysis**

## 4- Results

In this paper, “resilience and sustainable supply chain” was searched as a term in titles, abstracts, and keywords available in several databases including Emerald, Science Direct, Sage, and Google Scholar engine from 2011 to 2020. The results contained 39 papers as shown in Table (1).

**Table 1- Database/search engine and frequency of papers**

| Database/search engine | frequency |
|---|---|
| Emerald | 13 |
| Science direct | 9 |
| Sage | 1 |
| Google Scholar | 16 |
| Total | 39 |

At first, all papers were reviewed in terms of title, abstract and content. Then, a total of 15 papers dealing with supply chain resilience and sustainability (covering both concepts of resilience and sustainability) were selected as statistical population for meta-analysis. Tables 2 displays the growing trend in the number of papers published over recent years.

**Table 2- Research title, journal, year of publication and authors**

| No | Research title | Journal | Years/ Authors |
|---|---|---|---|
| **1** | Sustainability through Resilience | 6th AWBR International Co nference | 2011 Flint & et al [73] |
| **2** | Lean, agile, resilient and green: divergencies and synergies | International Journal of Lean Six Sigma | 2011 Carvalho & et al[74] |
| **3** | Supply Chain Performance Sustainability through Resilience Function | Winter Simulation | 2011 |

| No | Research title | Journal | Years/ Authors |
|---|---|---|---|
| | | Conference | Murino & et al [75] |
| 4 | Risk and Resilience in Sustainable Supply Chain Management_ Conceptual Outlines | International Logistics and Supply Chain Congress | 2012<br>Hanke and Krumme [76] |
| 5 | Supply Chain Resilience and Sustainability | Investment Research and Analysis Journal | 2014<br>Malindretos and Binioris [77] |
| 6 | Avoiding the Efficiency Trap: Resilience, Sustainability, and Antitrust | The Antitrust Bulletin | 2015<br>Hawker and Edmonds [78] |
| 7 | LARG index A benchmarking tool for improving the leanness, agility, resilience and greenness of the automotive supply chain | Benchmarking: An International Journal | 2016<br>Azevedo<br>& et al [79] |
| 8 | Supply Chain Criticality in Sustainable and Resilient Enterprises | Journal of Modelling in Management | 2016<br>Edgeman and Wu [80] |
| 9 | The role of Big Data in explaining disaster resilience in supply chains for sustainability | Journal of Cleaner Production | 2016<br>Papadopoulos & et al [81] |
| 10 | Marrying supply chain sustainability and resilience:<br>A match made in heaven | Transportation Research Part E | 2016<br>Fahimnia and Jabbarzadeh [10] |
| 11 | Building business sustainability through resilience in the wine industry | International Journal of Wine Business Research | 2017<br>Golicic & et al [82] |
| 12 | Revealing interfaces of supply chain resilience and sustainability: a simulation study | International Journal of Production Research | 2017<br>Ivanov [83] |
| 13 | Toward an integrated sustainable-resilient supply chain:<br>A pharmaceutical case study | Transportation Research Part E | 2017<br>Zahiri & et al [84] |
| 14 | Multi-objective optimization model for a downstream oil and gas supply chain | Applied Mathematical Modelling | 2017<br>Ghaithan et al [92] |
| 15 | A Multi-Objective Optimization Model for the Resilience and Sustainable Supply Chain: A Case Study | International Journal of Supply and Operations Management | 2020<br>Zamanian et al [85] |

The papers were reviewed and analyzed through expert opinions, Delphi technique, and dimensions and indicators according to Table (3). This table provided guidelines on how to filter information during the review of papers. In fact, it helped decompose every paper into a number of analyzable components. The information for filtration and classification of source contents can be found in Tables (4), (5), (6) as well as Figure (3).

**Table 3- Dimensions and indicators for analysis of papers**

| Indicators | Dimensions |
|---|---|
| Type of research, methodology, data collection procedure, validity | Methodology |
| Hypotheses/questions, analytical framework selected for model assessment | Theoretical framework |
| Economic, social, environmental, technical, organizational and cultural | Main research dimensions: |
| Main theme, variables and model | Content |

**Table 4- Indicators of methodology in the paper under study**

| Indicators | | Count | Percentage |
|---|---|---|---|
| Type of research (Research classification) | Applied | 9 | 60% |
| | Fundamental | 12 | 80% |
| | Strategic (combined applied and fundamental) | 6 | 40% |
| Methodology | Inferential | 2 | 13% |
| | Descriptive-analytical | 7 | 47% |
| | Mathematical modeling | 6 | 40% |
| | Simulation | 2 | 13% |
| Data collection procedure | Desk-library | 15 | 100% |
| | Observation | 6 | 40% |
| | Interview | 7 | 47% |
| | Questionnaire | 2 | 13% |
| Research validity | Yes | 10 | 67% |
| | No | 5 | 33% |

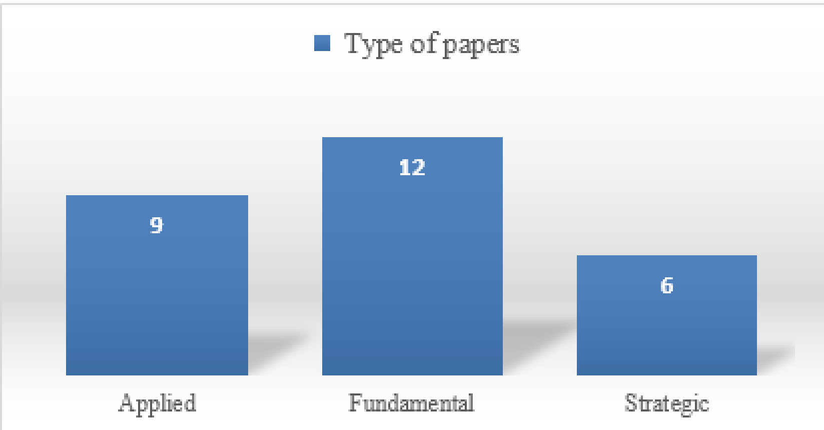


**Figure 3- Type of papers**

**Table 5- Research framework**

| Research framework | | Count | Percentage |
|---|---|---|---|
| **Question** | Yes | 3 | 20% |
| | No | 12 | 80% |
| **Hypotheses** | Yes | 2 | 13% |
| | No | 13 | 87% |
| **Conceptual model** | Yes | 12 | 80% |
| | No | 3 | 20% |

**Table 6- Dimensions of papers under study**

| Dimensions | Count | Percentage | Total Percentages |
|---|---|---|---|
| **Economic** | 15 | 100% | 31% |
| **Social** | 11 | 73% | 23% |
| **Environmental** | 8 | 53% | 17% |
| **Technical** | 9 | 60% | 19% |
| **Cultural** | 3 | 20% | 6% |
| **Organizational** | 2 | 13% | 4% |

In terms of research type, as shown in Table (4), 80% of papers were fundamental, 60% were applied, and 40% were strategic. The methodology of papers was descriptive-analytical by 47% and mathematical modeling by 40%. The data collection procedures involved desk-library by 100% and interview by 47%. In total, 67% of papers indicated adequate validity.

According to Table (5), only 20% of papers contained research questions, and 13% contained research hypotheses. In total, 80% of papers offered a conceptual model. According to Table (6), the economic, social, technical and environmental dimensions made up 100%, 73%, 60% and 53% of contents, whereas the cultural and organizational dimensions made smaller contributions by 20% and 13%, respectively.

The main theme of most papers revolved around the idea that sustainability is achieved through the creation of resilience in supply chains, sustainability is crucial for supply chain resilience, and the supply chain structure and resources involved the highest number of variables affecting the performance of resilience and sustainability in supply chains.

At the next stage, the variables in the paper models were integrated to provide a new categorization into primary and secondary indicators leading to supply chain resilience and sustainability (Table 7 and Figure 4). As can be seen, the supply chain resilience and sustainability involved structures by 34%, resources by 31% and capabilities by 13%. Innovation and production both made up 7%, while transportation and assessing the environmental both made up 4% of supply chain resilience and sustainability.

**Table 7- Components and sub-components retrieved from papers**

| Components | Sub-components | Count | Cumulative count | Percentage |
|---|---|---|---|---|
| **Assessing the Environment** | Internal | 1 | 1 | |
| | External | 1 | 2 | |
| | Capabilities | 1 | 3 | 4% |

| Components | Sub-components | Count | Cumulative count | Percentage |
|---|---|---|---|---|
| **Transportation** | Flexible | 1 | 1 | |
| | Lead time | 1 | 2 | |
| | Time periods | 1 | 3 | 4% |
| **System structures (SC)** | Location of facilities | 1 | 1 | |
| | Inventory level | 5 | 6 | |
| | Replenishment frequency | 1 | 7 | |
| | Specialized factories | 1 | 8 | |
| | Outsourcing | 1 | 9 | |
| | Stock level | 2 | 11 | |
| | Work closely with distributors | 1 | 12 | |
| | Modularity | 1 | 13 | |
| | Redundancy of central elements | 1 | 14 | |
| | Diversity | 2 | 16 | |
| | Enterprise human ecology | 1 | 17 | |
| | Feedback mechanisms | 1 | 18 | |
| | Manufacturing centers | 1 | 19 | |
| | Distribution Increased | 2 | 21 | |
| | Technology levels | 1 | 22 | |
| | Buffers | 1 | 23 | 34% |
| **Production** | Lead time | 2 | 2 | |
| | Unique identity | 1 | 3 | |
| | Type | 1 | 4 | |
| | Speed | 1 | 5 | 7% |
| **System resources** | Energy | 3 | 3 | |
| | Governance | 1 | 4 | |
| | Material | 3 | 7 | |
| | Funding | 1 | 8 | |
| | Number of suppliers | 1 | 9 | |
| | Information | 4 | 13 | |
| | Flexible | 1 | 14 | |
| | Equipment | 1 | 15 | |
| | Personal | 1 | 16 | |
| | Swift trust | 1 | 17 | |
| | Redundancy | 1 | 18 | |

| Components | Sub-components | Count | Cumulative count | Percentage |
|---|---|---|---|---|
| | Processes | 2 | 20 | |
| | Public-private partnership | 1 | 21 | 31% |
| **Innovation** | Social ecological | 1 | 1 | |
| | Re-engineering | 1 | 2 | |
| | Technological | 1 | 3 | |
| | Unique product | 1 | 4 | |
| | New experiences | 1 | 5 | 7% |
| **System Capabilities** | Adaptively | 1 | 1 | |
| | Learning | 1 | 2 | |
| | Repair capacity | 2 | 4 | |
| | Proficiency | 1 | 5 | |
| | Capacity surplus | 2 | 7 | |
| | Facility Fortification | 1 | 8 | 13% |

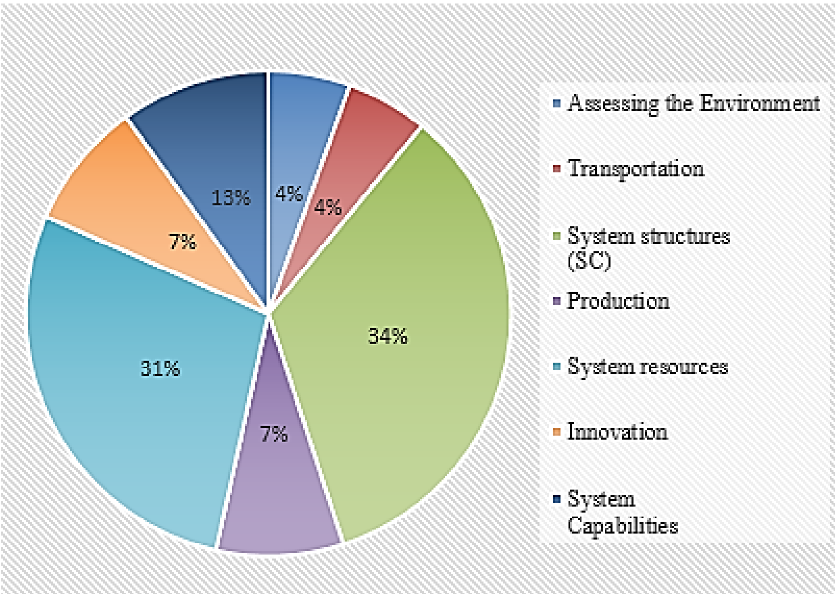


**Figure 4- Percentage of research components**

By matching, combining and establishing relationships between the conceptual models in the papers, according to Figure 5. a new conceptual model was proposed for resilient and sustainable supply chain approved by the panel of experts.

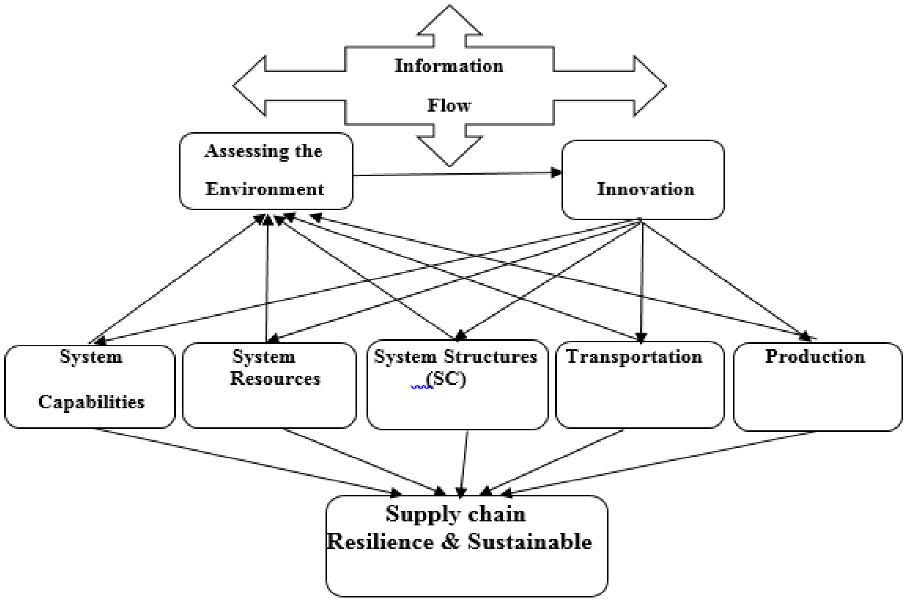


**Figure 5- New conceptual model of resilient and sustainable supply chain**

## 5- Discussion and conclusions

This paper involved a review of previous studies on resilient and sustainable supply chains published from 2011 to 2020. The papers were searched in Science Direct, Emerald, Sage and Google Scholar engine. Out of a total of 39 papers covering both resilience and sustainability dimensions, 15 papers were selected as the statistical population. The number of papers published in recent years suggests a growing trend of concentration on resilient and sustainable supply chains. The findings of this research emphasized that sustainability of supply chains could be achieved through resilience. In this research, the theoretical framework of each paper was explored. The meta-analysis and integration of steps from theoretical frameworks were adopted to propose a novel conceptual model. Given its dimensions and components, the new model proved to be more comprehensive than previous ones, offering several strengths. In the newly proposed conceptual model, the resilience and sustainability of supply chain are contributed by several components including structure (34%), resources (31%), supply chain capabilities (13%), innovation and production (7%), and transportation and environmental assessment (4%).In the new conceptual model, all supply chain components of structure, capabilities, resources, transportation, and products were examined in terms of environmental evaluation and innovation. The feedback from each component reflected a close relationship with regard to the flow of information sharing throughout the process, leading to supply chain integration, resilience, and sustainability. Since findings indicate the growing importance of global energy consumption and a large research gap in this area, it is highly recommended that future studies focus on supply chain sustainability and resilience in the energy sector.

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