A comprehensive review of Network Design in a Sustainable Supply Chain: Focus on the social dimension

Yves Gouret[1], Ilhem Slama [1], Evren Sahin[1], Zied Jemai[1]

Abstract **Amid growing concerns over the environmental and social impacts of supply chains, sustainable network design has become a key focus in both research and practice. This paper presents a comprehensive review of 184 publications on network design in sustainable supply chains. We explore how sustainability dimensions, especially the often-overlooked social aspect, are integrated into network design decisions. The review categorizes the main modeling approaches, objectives, and uncertainty considerations, and highlights emerging trends such as circular economy and responsible sourcing. Finally, we identify research gaps and outline future directions, with a particular emphasis on enhancing the social sustainability of supply chain networks.**

I. Introduction

Over the past years, supply chain has become a key component of companies' strategy and performance. In parallel climate change and scarcity of resources is now a major challenge for all our societies. According to McKinsey [30], 90% of consumer sector companies' environmental impact is related to supply chains. As a significant impact is related to the design of the network (transportation, factory or DC locations, choice of vendors) many scholars have addressed this new research area named Sustainable Supply Chain Network design (SSCND). From 2014 to 2025, 184 papers have been dedicated to this topic, more than 20 per year for the last 5 years. Given the increasing attention this subject is receiving, we felt it was valuable to assess the current state of research in the field.

Some literature review already exists on SSCND. We found 6 articles. Four are dealing partially with the scope we are considering and two have a close scope [1] and [2]. Our contribution to the research is the following:

- We have added 50 more recent articles to the scope [1] was written in 2015 and [2] last article was published in 2022
- Articles including closed-loop supply chain: [2] excluded this topic from its scope of study
- A focus on social aspects of sustainability.

The remainder of the paper is structured as follows. Section II describes the research methodology, and the bibliometric analysis used to identify and classify the 184 selected publications. Section III considers the problem dimensions. First subsections A, B and C explores how the three sustainability dimensions (economic, environmental and social) are incorporated into network design models, including the criteria used for each. Subsection D outlines the problem contexts addressed in the literature, while Subsection E focuses on the activity sectors most frequently represented in the case studies. subsection F analyzes the geographical distribution of the studies across different regions. Subsection IV provides an overview of the modeling approaches, solution methods, and tools employed in the reviewed work. Finally, Section V discusses the limitations of this review and proposes avenues for future research, with a particular emphasis on the integration of social sustainability in supply chain network design.

II. Bibliometrics

Before starting the research, we started framing the analysis grid to identify the main keywords and concepts based on some literature review articles related to parts of the topic. The selection of the papers Fig.1. has been made from the Scopus data base. We first selected the papers for a period starting in 2014 up to 2025 which is usual for this literature review exercise.

We launched the first search with the keywords "Supply chain" AND "network design" AND "sustainab*". We used "sustainab*" to get the papers for which "sustainability" or "sustainable" were quoted either in the article, abstract or the keywords. After some iterations, we launched a new search with "supply chain" AND "network design" AND («sustainable*" OR "green" OR "ESG" OR "CSR") we found a total of 758 articles.

Two remarks, first the words ESG (Environmental Social Governance) and CSR (Corporate Social Responsibility) are not common in the papers concerning sustainability in supply chain only 2 out of 758. Second, it is very important to search with the 2 keywords "sustainab*" and "green" as 66 papers are only referring to green supply chain with no mention of sustainability or sustainable supply chain.

As the search is bringing a big number of papers, which volume would have been difficult to use in a detailed study, we decided to focus on the papers for which the keywords we have defined were all three in the title of the article.

With the same search with the keywords "supply chain" AND "network design" AND ("sustainab*" OR "green" OR "ESG" OR "CSR") in the title we selected 214 articles. We extracted these articles analyzed one by one the abstracts and excluded the ones related to literature review, duplicated, non-available, retracted or out of our scope (use of the word

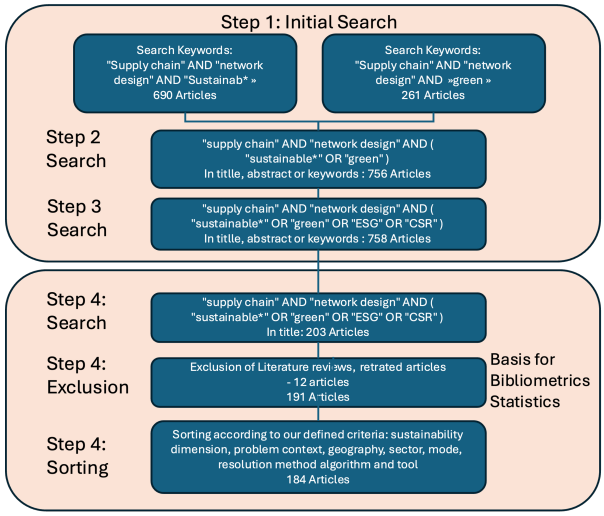
*Research supported by "Chaire Supply Chain Centrale Supelec".

[1] CentraleSupélec, Laboratoire Genie Industriel, Université Paris-Saclay, 3 rue Joliot-Curie, 91190 Gif-sur-Yvette, Ile-de-France, France

{yves.gouret; ilhem.slama; evren.sahin; zied.jemai}@centralesupelec.fr)

sustainable or sustainability for the ability to be maintained, not related to environment).

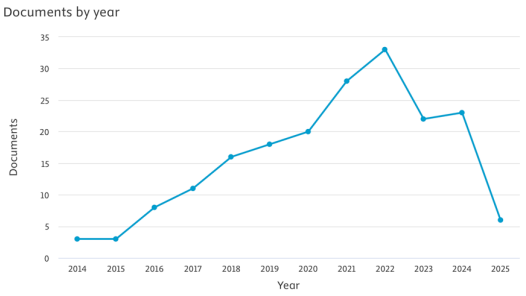
Fig.1. Steps of our paper selection



Finally, in our last step, from the extraction of all selected articles, we did a manual review of each article abstract to assign them all the criteria defined in our analysis grid (sustainability dimension, problem context, geography, sector, model, resolution method, algorithm and tool).

We can see on the Fig.2. hereby that the number of articles published has been constantly growing, up to 2022, decreasing a bit since then, but remaining above 20 papers per year. There is a steadily growing base line with an outlier in 2021 & 2022 probably due to covid related articles.

Fig.2. « supply chain » AND « network design » AND (« sustainab* » OR « green » OR « ESG » OR « CSR ») In title



In the analysis hereafter, due to the high number of articles in scope (184), numerical analysis has been made based on abstracts, detailed analysis or focus points have been made on the article content.

III. Problem Dimensions

Also called the three bottom lines in many publications [21], the three sustainability dimensions are the economic, the environment and the social dimensions. Since years, the research related to sustainable supply chain was mainly focused on economic and environmental dimensions which are easier to measure. We can see now a growing number of papers, integrating the social dimension. When we look at the paper [1], we can see that in 2015, out of 87 papers considered in the review, only 13 were including social aspects in their model (around 15% of the total). In our review, 80 out of 184 (43%) of the papers is considering the social aspects which is a noticeable increase.

A. Economic

The Economic dimension is included in all papers in most cases from the cost perspective. The costs considered are generally transportation costs, warehousing costs, production or purchasing costs [3][5]. We generally have a mix of variable costs (in most cases cost per unit). But in some cases, we also have fixed costs in the models such as costs to set up a new facility or to order transport.

Some papers also include the profit. In most cases like in [4] profit and costs are grouped on the same objective function. It is interesting to notice that in some of the papers [6][4][5], the economic objective function is set as a benefit minus costs, meaning that costs and benefits are considered at the same level. As in most cases the costs considered are gross margin costs, it would be interesting to consider the gross margin impact of the revenue instead of total revenue.

B. Environment

The environmental aspect is also considered in nearly all papers and in general through the reduction of CO2 emissions [23]. In some articles like [24] the focus is more on the use of resources such as water or energy [22].

C. Social

The social aspects of sustainability attract more and more attention from scholars. Nevertheless, the type of social aspects (number of jobs, customer satisfaction) and their measurement are not fully mature as there is a great variety of ways to consider social aspects in their nature as well as in the indicators measured. We will make of focus on this topic in the section VIII.

The most common is the number of job opportunities [13][17],[18],[19]. Other papers propose other indicators such as the Gini index [20]. Another interesting indicator proposed is the Corporate Information Transparency Index (CITI) [21]. A small number of articles are also considering occupational safety [22] as a target.

Finally, some are considering Customer Service Level (CSL) [13] or customer satisfaction, [16] which is more questionable as service rate should probably be more linked to profit and economic dimension.

D. Type of SSCND problems considered

The most common problems treated in the papers are the definition of optimum number of locations (factories, distribution centers, choice of vendors) and their positioning. Another important use case is the allocation problem of resources of production, [26] between facilities, routing is also frequently included.

The great majority of the papers is focused on the strategic decisions of the supply chain [1]. Nevertheless, some articles are also considering more tactical decisions such as tactical product allocation, production plans etc. [26].

Closed-Loop Supply Chain (CLSC) is cited in about 1/3 of the papers. This is a trendy topic, fully aligned with the current more general focus on circular economy. It is interesting to note that concepts around circular supply chain, closed loop and reverse supply chain are not all perfectly aligned between the different articles. Those concepts and their definition are the subject of specific research such as [3] where we can see that we are getting towards a consensus on circular Supply Chain definition. We have not noticed such a consensus on closed-loop supply chain or reverse logistics.

E. Activity Sector

Approximately half of the papers base their numerical experiment on data from a real case. The most represented sector is the Food&Beverages with 26 cases, followed, above ten occurrences, by healthcare sector with 12 cases and industrial goods with 13 cases. Below ten occurrences we have Automotive (9 cases), Technology (9 cases), Agriculture (6 cases), Energy (3 cases), Home&Office (3 cases), Steel (2 cases), Chemicals (2 cases), Construction (1 case).

Some cases (9) are in two sectors. For example, the case [15] on a strawberry network has been assigned to Agriculture and Food&Beverages. We can see in these use case an under-representation of consumer goods (except food) or wholesale and retail sectors in the case studies compared. It could be an opportunity for future research.

F. Geography

For some cases, the numerical experiments are based on dummy data, but for 20% of the cases (35), they are based on cases localized in a country or geographical zone cited in the article. The continent the most represented is Asia which accounts for ¾ of the cases (27), Iran accounting for 80% of Asian articles (22), second being China (4). A few cases are concerning North America (3) and Europe (3), Australia (1) and Columbia (1). There is no case for Africa.

IV. Models Resolution & Tools

There is a great variety of models developed in the different papers. It is consistent with the fact that the reality of the existing supply networks is also very different. Second factor, the number of objectives and the way we want to address them (single or multi objectives). Finally, it also depends on the number of nodes and parameters. Some models are can not be used with a high level of combinations. Despite this great dispersion of cases, we can see some common points and interesting insights from the papers we have considered, and we will describe the main outputs of our analysis that we will summarize in this review.

Great majority of the papers concerns multi-objective models but, in some papers, the problem which is multi-objective by nature is transformed into single-objective one.

A. Single-objective model

Single objective models are less numerous than the multi-objective ones but still represent a significant number of papers. As we are dealing in SSCND we generally have initially at least two objectives (economic and environment in general) or three (economic, environment, social). Sometimes, we even split the objectives within one dimension (ex: CO2 emissions and water consumption for the environmental dimension). To transform theses multi-objective cases in single objective ones, different methods are used. In some, the weighted sum method is used like in [9]. It means that the different objectives, units of measurement are harmonized and in a second step are applied a weight.

A second method is the transformation of objectives in constraints as in [10] where the objective function is the cost while the sustainability dimensions, in this case (resilience, CO2, energy and employment) are constraints.

A third method is to transform the environment objective in cost, generally the CO2 like in [8] where the CO2 is considered in the cost function together with transportation, warehousing and inventory costs. The single objective model can be deterministic like in [12] or stochastic like in [12].

B. Multi-objective models

Unsurprisingly, the most common model is a multi objective one (generally two or three objectives) corresponding to the sustainability dimensions embraced in the case. The first objective is generally the cost objective related to the economic dimension, the second one, the environmental objective and sometimes (about half of the cases) the social dimension. It is interesting to notice that we found only 1 paper with only the economic and social dimensions considered and no environmental dimension [11].

We found a lot of cases using Mixed Integer Linear Programming (MILP) or in some cases MOMILP (Multi Objective Linear programming. Somes fewer cases are using nonlinear models (MINLP) [28], [29].

We can also see a lot of models trying to model uncertainty, which is typical of a real supply chain. It can be uncertainty of the demand, lead-times, of production etc. The stochastic models are used a lot in the most recent cases. This uncertainty in the model is also managed through possibilistic methods (17 papers). Some scenarios can also be included in the models (10 papers) and some others are using fuzzy methods (42).

In the resolutions, the methods are very numerous. First, we can see that a great number of papers is describing hybrid methods (different models or resolution methods are used within the same case). We also see a lot of meta-heuristic and heuristic algorithms. Genetic algorithms (20 occurrences) such as NSGA2 (12) or SPEA2 (2) are quite common. We also found a significant usage of the TOPSIS (6) Multi-Objective Grey Wolf optimizer (MOGWO) (3) methods (multicriteria method) or swarm algorithms (sometimes called MOPSO Multi Objective Particle Swarm Optimization).

C. Tools

The most used tool in the cases we studied is GAMS (CPLEX solver) as in [10] and we also see Lingo like in [14].

V. Future Research Directions

We can see from this review that, even if a lot of articles have been published, the newness of supply chain and sustainability as a research area, has left some research gaps.

Limitations

As the number of articles found initially, looking for our keywords “supply chain», «sustainability” “ESG” “CSR” and “network design” in abstracts, keywords and title was very high (690) we finally selected only the ones for which the keywords were in the title. In the 690 – 214 = 476 articles, we might have missed some interesting elements that could have completed our study.

Focus on Social aspects

We can see in the different papers dealing with the social aspects of sustainability (as stated in the part III C) that there is no shared frame nor standard KPI’s to track the social impact of a supply chain when designing the network. We think there are some great opportunities of future research on that dimension.

As a method, we think it could be interesting have a review of the 17 Sustainability Goals promoted by the United Nations. On these 17 Goals, 11 include a target linked to a social element (No poverty, Zero Hunger, Good health and well-being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and clean Energy, Decent Work and Economic Growth, Reduced inequalities, Sustainable Cities and Communities, Peace Justice and strong institutions). As a second step, it would be interesting to identify for each of the targets related to the 17 goals, which are the supply chain levers which can impact these targets with a KPIs definition. As an example, the target 10.1 which is “By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average” could be linked to an indicator that would influence the location of sites in the most suitable regions to improve the KPI.

The different indicators, that could be generated can be very numerous. The challenge is to include those different KPI’s in a single model. If we consider all indicators separately the model will be too big for computing, and the multi criteria decision between criteria will be difficult. To solve this problem, a direction could be, with a specialist of the field (social sciences) to develop composite KPI’s that would best represent the impact of supply chain on a given dimension. For the social aspects it could be a mix of wage, gender equality, occupational safety for example that we could gather in a composite index such as the HDI (Human Development Index) which is a mix of life expectancy, education, GNI (Gross National Income per Capita) for example. As a conclusion, many solutions can probably be explored and a better definition and framing of the social dimension is needed and it would be a very useful area for future research.

Other potential research directions

Very few studies are made on global supply chains with long lead-times (sea shipments). This could be an interesting area, as the structure of costs components of a supply chain would vary a lot together with the purchasing prices. It would be interesting to study the sensitivity of costs of supply chain vs purchasing cost in this environment. This is particularly true in a moment where a lot of companies are considering re-localization of production.

On a topic which is related to the above, very few papers study the impact of the network on the stocks. According to the lead-times, the stock policy should evolve and together with the stocks, the holding costs (physical distribution and financial costs) as well as the level of Excess and Obsoletes can vary a lot and could be included in the models.

Another area to be investigated would be the industrial and consumer goods sectors for which we have seen very few cases while they represent a great amount of supply chain challenges. Their supply chains are generally very internationalized and mature, and it would be interesting to develop some cases related to these two activity sectors.

During our research we haven’t found papers dedicated to a detailed analysis of the models used in sustainable network design and their use cases. It would be interesting to have such research to have a global assessment of the situation, to describe the potential scope of each method, its advantages and drawbacks to better identify the current gaps.

VI. Conclusion

This paper presents a comprehensive review of 184 publications on network design in sustainable supply chains, with a particular emphasis on the integration of the social dimension. Our analysis reveals that while environmental and economic aspects are widely addressed, social sustainability remains underrepresented, both in terms of modeling and practical implementation. The reviewed studies highlight the growing diversity of modeling approaches, solution techniques, and contextual applications across various sectors and geographies.

Despite significant progress, several gaps persist. Notably, there is a need for more holistic models that balance all three pillars of sustainability, and for deeper exploration of real-world social indicators such as labor rights, equity, and community impact. The integration of uncertainty, circular economy principles, and digital technologies also presents promising avenues for future research.

References

[1] Majid Eskandarpour, Pierre Dejax, Joe Miemczyk, Olivier Péton. “Sustainable supply chain network design: An optimization-oriented review”. Omega, 2015, 54, pp.11-32. 10.1016/j.omega.2015.01.006 .hal-01154605

[2] Madani, B.; Saihi, A.Abdelfatah, A. “A Systematic Review of Sustainable Supply Chain Network Design: Optimization Approaches and Research Trends.” Sustainability, 2024, 16, 3226. https://doi.org/10.3390/su16083226

[3] Laura Masruroh, “Circular Economy and Supply Chains: Definitions, Conceptualizations, and Research Agenda of the Circular Supply Chain Framework.” Circular Economy and Sustainability, 2023,3:35–75

[4] Alinezhad, M., Mahdavi, I., Hematian, M. et al. “A fuzzy multi-objective optimization model for sustainable closed-loop supply chain network design in food industries.” Environ Dev Sustain, 2022, 24, 8779–8806.

[5] Mariam Ameli et al, “Bi-objective Stochastic Programming Model for Green Closed-loop Supply Chain NetworkDesign in

Presence of Sale and Leaseback Transactions.", International Journal of Supply and Operations Management, November 2022, Volume 9, Issue 4, pp. 417-447

[6] Yuchun Zhang, Yanan Wang, Bharosh Kumar Yadav. "Planning in Analyzing the Sustainable Closed-Loop Supply Chain Network Design." Application of Circular Economy and Uncertainty, First published: 08 February 2022

[7] Rezakhanlou, M., Mirzapour Al-e-Hashem, S.M.J. "A dual-channel multi-objective green supply chain network design considering pricing and transportation mode choice under fuzzy uncertainty." Environ Dev Sustain, 2024.

[8] Zhou, L.; Zhang, D.; Li, S.;Luo, X. "An Integrated Optimization Model of Green Supply Chain Network Design with Inventory Management." Sustainability, 2023, 15,12583.

[9] Abbasi, S., Daneshmand-Mehr, M. & Ghane Kanafi, "A. Green Closed-Loop Supply Chain Network Design During the Coronavirus (COVID-19) Pandemic: a Case Study in the Iranian Automotive Industry." Environ Model Assess, 2023 28, 69–103 (2023). https://doi-org.ezproxy.universite-paris-saclay.fr/10.1007/s10666-022-09863-0

[10] Lotfi, R., Mehrjardi, M.S., MohajerAnsari, P. et al. Antifragile, sustainable, and agile supply chain network design by considering resiliency, robustness, risk, and environmental requirements. Environ Sci Pollut Res 30, 106442–106459.

[11] Razavi, N., Gholizadeh, H., Nayeri, S., & Ashrafi, T. A. "A robust optimization model of the field hospitals in the sustainable blood supply chain in crisis logistics." Journal of the Operational Research Society, 2020, 72(12), 2804–2828.

[12] Reyhaneh Zoljoudi Zarandi, Atousa Shafiee Motlaq-Kashani, Mohammad Sheikhalishahi, "A two-echelon sustainable multi-route location routing problem for biomass supply chain network design considering disruption", Computers & Chemical Engineering, 2024, Volume 187, 108744

[13] Yozgat, S., Erol, S. "Sustainable Closed-Loop Supply Chain Network Design and Optimization." In: Xu, J., Altiparmak, F., Hassan, M.H.A., García Márquez, F.P., Hajiyev, A. (eds) Proceedings of the Sixteenth International Conference on Management Science and Engineering Management – 2024, Volume 1. ICMSEM 2022. Lecture Notes on Data Engineering and Communications Technologies, vol 144. Springer, Cham.

[14] Zohal, M., & Soleimani, H. "Developing an ant colony approach for green closed-loop supply chain network design: a case study in gold industry." Journal of Cleaner Production, 2016, 133, 314–337.

[15] Baghizadeh, K., Cheikhrouhou, N., Govindan, K., & Ziyarati, M. "Sustainable agriculture supply chain network design considering water-energy-food nexus using queuing system: A hybrid robust possibilistic programming." Natural Resource Modeling, 2022,35(1), n/a.

[16] Rabbani, M., Hosseini-Mokhallesun, S. A. A., Ordibazar, A. H., & Farrokhi-Asl, H. "A hybrid robust possibilistic approach for a sustainable supply chain location-allocation network design." International Journal of Systems Science. 2022, Operations & Logistics, 7(1), 60–75.

[17] Olfati, M., & Paydar, M. M. "Towards a responsive-sustainable-resilient tea supply chain network design under uncertainty using big data." Socio-Economic Planning Sciences, 2023,88, 101646.

[18] Ala, A., Goli, A., Mirjalili, S., & Simic, V. "A fuzzy multi-objective optimization model for sustainable healthcare supply chain network design." Applied Soft Computing, 2024, 150, 111012

[19] Tsao, Y.-C., Tesfaye Balo, H., & Lee, C. K. H. "Resilient and sustainable semiconductor supply chain network design under trade credit and uncertainty of supply and demand." International Journal of Production Economics, 2024,274, 109318.

[20] Battaïa, O., Guillaume, R., Krug, Z., & Oloruntoba, R. "Environmental and social equity in network design of sustainable closed-loop supply chains." International Journal of Production Economics, 2023, 264, 108981.

[21] Guo Y.; Yu J.; Liu W.; Zhang Y.; Zhang M. "Modeling and solution for sustainable supply chain network design problem in manufacturing industry", Computer Integrated Manufacturing Systems, CIMS, 2021

[22] Khalili-Fard, A., Sabouhi, F., & Bozorgi-Amiri, A. "Data-driven robust optimization for a sustainable steel supply chain network design: Toward the circular economy." Computers & Industrial Engineering, 2024,195, 110408.

[23] Tavana, M., Sohrabi, M., Rezaei, H., Sorooshian, S., & Mina, H. "A sustainable circular supply chain network design model for electric vehicle battery production using internet of things and big data." Expert Systems, 2024, 41(7), n/a.

[24] Hamid Saffari, Morteza Abbasi, & Jafar Gheidar-Kheljani. "A sustainable and reliable model for iron closed-loop supply chain network design with considering risk and lateral transmision and developed multi-objective decision-making method." TaṣMīm/GīRī va TaḥQīq Dar ̒Amaliyyāt (Online), 2023, 8(3), 691–713.

[25] Saeid Kalantari, Hamed Kazemipoor, Farzad Movahedi Sobhani, & Seyyed Mohammad Hadji Molana. "Sustainable closed-loop supply chain network design: heuristic hybrid approach with considering inflation and carbon emission policies.", 2023, TaṣMīm/GīRī va TaḥQīq Dar ̒Amaliyyāt (Online), 8(4), 931–953.

[26] Wang, J., Wan, Q., & Yu, M. "Green supply chain network design considering chain-to-chain competition on price and carbon emission. "Computers & Industrial Engineering, 2020, 145, 106503.

[27] Masruroh, N.A., Rifai, A.P., Mulyani, Y.P. et al. "Priority-based multi-objective algorithms for green supply chain network design with disruption consideration." Prod. Eng. Res. Devel., 2024, 18, 117–140.

[28] Rahmani, S., & Goli, A. "Robust sustainable canola oil-based biodiesel supply chain network design under supply and demand uncertainty. "Environmental Science and Pollution Research International, 2023, 30(36), 86268–86299.

[29] Hasani, A., Mokhtari, H., & Fattahi, M. "A multi-objective optimization approach for green and resilient supply chain network design: A real-life case study. Journal of Cleaner Production, 2021, 278, 123199.

[30] Bové A., Swartz S. "Starting at the source: Sustainability in supply chains," Mc Kinsey Report on Sustainability & Resource Productivity 2016