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Circular Economy & Industry in 2035

Supply chain

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1. Definitions

1.1. Defining the report topic

The origins of supply chains date back to the fourth century BC, when Alexander the Great conceived the idea of sending food and fodder supplies ahead of the army's movements. These logistics activities were first grouped under the term "supply chain" (SC) in 1982 (Oliver and Webber, 1982).

The supply chain's mission primarily consists of managing flows and inventories from end to end, with the goal of efficiency and customer satisfaction: "the right product to the right place at the right time at the right price." Although definitions vary and the concept remains fluid (Min et al. 2019), we adopt the following CSCMP definition[1]:

"Supply chain management encompasses the planning and management of all activities related to sourcing, production, and all logistics management activities. Importantly, it also includes coordination and collaboration with distribution partners, which may be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies."

The supply chain and its activities center on four main actors, shown in the following figure:

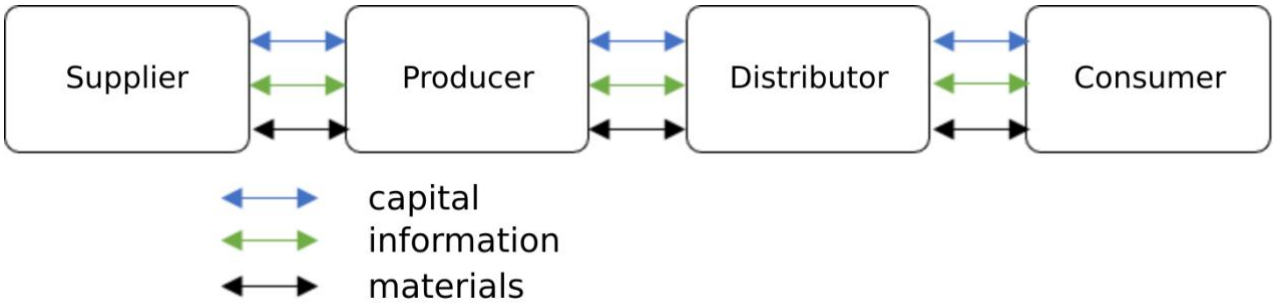


Figure 1: Overview of the supply chain, inspired by Fugate et al. (2006)

1.2. Relevance to the study

Numerous environmental challenges are currently identified within supply chains and are similar to those of the circular economy[2]: limiting the use of nonrenewable resources and materials, reducing greenhouse gas emissions, minimizing resource waste, and reducing the amount of waste produced. For example, supply chains generate more than 90% of an organization's greenhouse gas emissions, according to a 2022 Ernst & Young report[3].

The supply chain is also directly linked to certain circular economy principles[4]: sustainable sourcing, ecodesign, and improved waste management and recycling. On this last point, the transportation and logistics sectors are subject to extensive waste-management requirements, particularly in connection with the 2015 ecological transition law[5], which is based on the three R's: reduce, reuse, and recycle.

[1]https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx#:~:text=CSCMP%27s%20Definition%20of%20Supply%20Chain,and%20all%20logistics%20management%20activities.

[2] https://www.supplychaininfo.eu/dossier-supply-chain/quels-enjeux-environnementaux-supply-chain-management/

[3] https://www.ey.com/en_gl/supply-chain/supply-chain-sustainability-2022

[4] https://www.ecologie.gouv.fr/leconomie-circulaire#

[5] https://www.logtex.fr/logistique-valorisation-des-dechets/

More broadly, the link between the supply chain and the circular economy is reflected in circular supply chain initiatives (De Angelis et al., 2018).

These circular approaches encourage manufacturers to reuse raw materials such as plastic, metal, and cardboard, and to refurbish and resell goods rather than discard them, drawing on the three R's mentioned above[6]. This new system thus involves rethinking the network of actors and their original functions to create a "closed-loop" supply chain (Fulconis & Philipp, 2016).

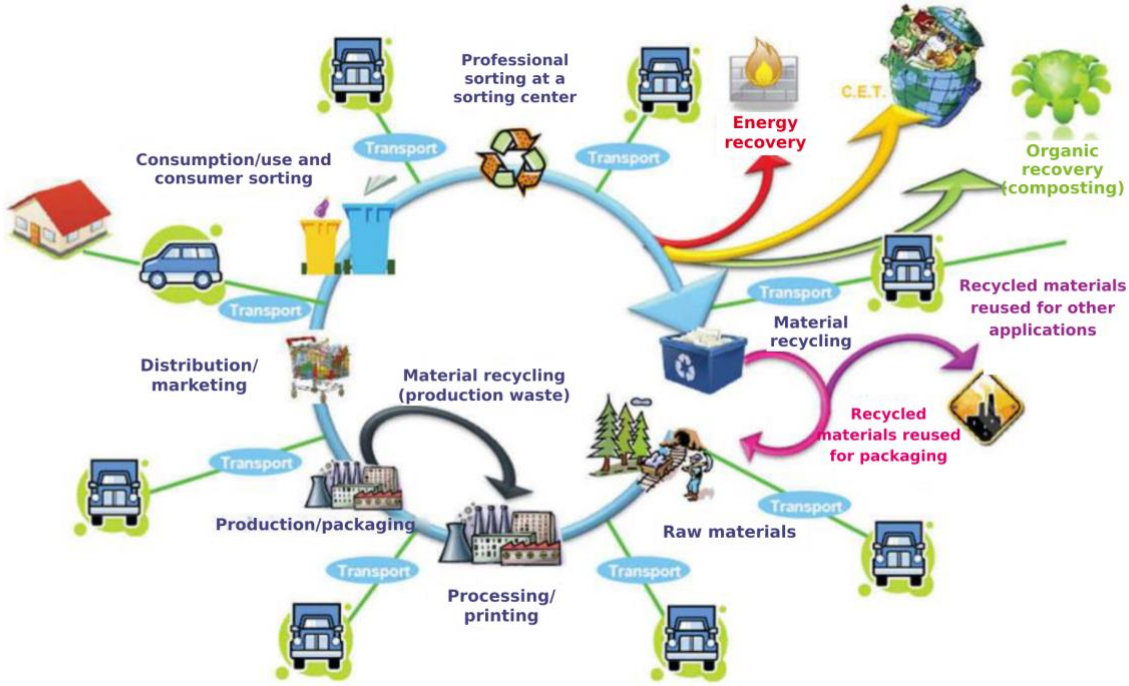


Figure 2—Closed-loop supply chains (Fulconis & Philipp, 2016, p.188).

Moving from a conventional supply chain to a circular supply chain also requires a change in objectives. Indeed, conventional supply chains primarily pursue economic performance, based both on specialization of the parts used—the proliferation of materials and components that add functionality—and on the pursuit of economies of scale: Large factories reduce fixed costs for products delivered across a wide area through an elaborate distribution system[7].

The transition to a circular supply chain also reverses the logic of flows (Interview A.E.). In a conventional supply chain, raw-material flows are consolidated, as in mining, then distributed among different companies and, finally, among each company's different products. In a circular supply chain, by contrast, the raw-material flow is smaller, for example through the use of recycled products or components. The objective is then to consolidate these flows to reach a critical scale for recycling and new production.

1.3. Key questions for the future

A first question concerns supply chain actors' ability to place the three R's of the circular economy—reduce, reuse, and recycle—at the heart of strategic supply chain decisions. **In other words, whereas strategic supply chain management currently focuses on optimizing customer satisfaction, could the focus shift toward managing natural resources and raw materials?**

[6] https://www.oracle.com/scm/circular-supply-chain/#:~:text=A%20circular%20supply%20chain%20is,and%20resell%20previously%20owned%20goods.

[7] https://hbr.org/2021/06/circular-supply-chains-are-more-sustainable-why-are-they-so-rare

A second question concerns the supply chain's capacity for resilience and sustainability in the face of challenges in accessing resources and raw materials, and the synergy between that capacity and a circular supply chain design. **To what extent will the move toward a sustainable, resilient supply chain be linked to its circularity?**

Third, consumers' actual participation in the supply chain and their responsibility within a closed-loop supply chain must be examined. **To what extent could consumers become participants in supply chain decisions and priorities**, for example by taking part in product ecodesign? **Are they prepared to assume their share of responsibility and revise their satisfaction criteria to align with the operation of a circular supply chain**, such as accepting different product delivery times to reduce deliveries' environmental impact? Participation may also encompass other noneconomic partners, such as local authorities in waste management.

2. Retrospective analysis

2.1. Past developments

From operational logistics to strategic supply chain management

The supply chain, previously understood as an operational logistics activity, has become a strategic dimension for businesses. It is central to business performance and is becoming a real competitive advantage (Li et al., 2006). A strategic supply chain is collaborative, agile, resilient, and digital[8].

This growing strategic dimension is primarily explained by the fact that businesses increasingly view supply chains as a means of satisfying customers and securing their loyalty. Delivery conditions—time, quality, and price—have become purchasing criteria for customers and allow companies to distinguish themselves from competitors. Customer satisfaction therefore becomes a supply chain priority, especially because a product's distribution policy—the arrangements used to make products accessible to consumers—supports its commercialization and thus increases the company's revenue and/or market share[9]. From this perspective, the supply chain's main objective is efficient delivery to customers as quickly as possible, while seeking to reduce costs.

The supply chain's strategic orientation is primarily based on the relationship between the producer and the supplier, its two main actors. Its design and the entirety of its interactions are structured around this dyadic relationship.

Greater use of new technologies for supply chain efficiency

New technologies—the Internet of Things, big data, blockchain, and others—are increasingly used in the continuing effort to better meet consumer needs (Kückelhaus and Chung, 2019). Connected objects provide real-time information on production progress, inventories are managed in real time, and predictive analysis of needs enables better resource allocation. The supply chain thereby gains in productivity and, above all, flexibility[10]. The flexibility achieved through new technologies strengthens companies' competitive advantage through their supply chains (Fosso-Wamba et al., 2015; Gunasekaran et al., 2017).

A more complex downstream chain with e-commerce

The downstream part of the supply chain has become more complex with the major expansion of e-commerce. E-commerce is experiencing strong overall growth, with nearly €147 billion spent online in France

[8] https://www.ascm.org/ascm-insights/what-is-supply-chain-strategy/

[9] https://modelesdebusinessplan.com/blogs/infos/distribution-mix-marketing

[10] https://www.synox.io/cat-smart-logistics/supply-chain-4-0-industrie-du-futur-iot/

in 2022[11]. This development has made consumers increasingly demanding about delivery conditions: ever faster delivery—Amazon Prime guarantees delivery within twenty-four hours—to a location where they are present, such as their home, or a nearby location, such as a pickup point; sometimes with associated services, such as taking back and/or assembling a small household appliance[12]. Companies must therefore adopt omnichannel strategies to better meet consumers' new habits. An omnichannel strategy aims to increase the number of purchasing and distribution channels—direct sales, stores, online, social media, and so on—while providing consumers with the same service regardless of their chosen channel (Min et al., 2019).

At the same time, the emergence of increasingly popular traditional online shopping events—Black Friday, Cyber Monday, and others—concentrates demand within a very short period. On Black Friday alone in 2023, consumers spent $9.8 billion, an increase of 7.5% over the previous year[13]. Companies must therefore be able to deliver a large quantity of products to a large number of customers in a very short time.

Finally, the option to return a product purchased online plays an important role in consumers' purchasing decisions (Rogers and Tibben-Lembke, 2001). Managing product returns requires a dedicated supply chain, known as "reverse logistics," which must handle each return individually: a change of mind, a defective item, an item damaged in transit, and so on. Although returns have surged, rising from 8% to 16% between 2019 and 2022 in the United States[14], returns management remains difficult to standardize, and the steps involved are time-consuming and costly for companies: The item must be unpacked, inspected, repackaged, and rerouted. As a result, few products are offered for sale again through their original channel. Product returns therefore amount to an ecological scourge[15], given the distances traveled and the waste generated when returned products are not recovered—"forgotten" on shelves or simply destroyed, as with Amazon's destruction of 3.2 million unsold products in France in 2018[16].

2.2. Current developments

Toward a dynamic supply chain and the emergence of new actors

The static approach, in which identified actors perform specific activities within the supply chain, is gradually giving way to a more dynamic view. Supply chains are no longer closed systems seeking control and optimization but open ecosystems that bring in actors as needs arise (Wieland, 2021). Alongside traditional actors (see 1.1), new ones are emerging that specialize in a particular part of the supply chain. For example, many startups offer services or platforms to manage final delivery to consumers, such as Onfleet, Nuro, Postmates, Starship Technologies, Matternet, Amazon Flex, and PiggyBee[17]. Consumers themselves can become supply chain actors by handling all or part of the delivery to the end customer through "crowd logistics"[18].

Figure 3 below illustrates the shift from a conventional, rigid, linear approach, on the left of the diagram, to a dynamic approach, on the right. In the proposed dynamic configuration, the producer or original equipment manufacturer (OEM) is positioned at the center of a system that includes suppliers and

[11] https://www.fevad.com/bilan-du-e-commerce-en-france-les-francais-ont-depense-pres-de-147-milliards-deuros-sur-internet-en-2022/

[12] https://blogistics.fr/les-differents-types-de-livraison-du-dernier-km/

[13] https://www.retaildive.com/news/winners-losers-black-friday-2023/700647/

[14] https://www.wedemain.fr/respirer/ce-quil-se-passe-quand-vous-faites-un-retour-produit-amazon/

[15] https://www.maddyness.com/2020/06/16/fleau-ecologique-retours-colis/

[16] https://www.lemonde.fr/televisions-radio/article/2019/01/11/amazon-vendeur-de-destruction-massive_5407944_1655027.html

[17] Top seven companies and startups for last-mile delivery in 2023 https://onfleet.com/blog/last-mile-delivery-companies/

[18] https://www.le-coursier.fr/blog/definition_crowd_logistics

consumers, as well as service providers and digital platforms. This transition is facilitated by companies' digital transformation and their use of new technologies.

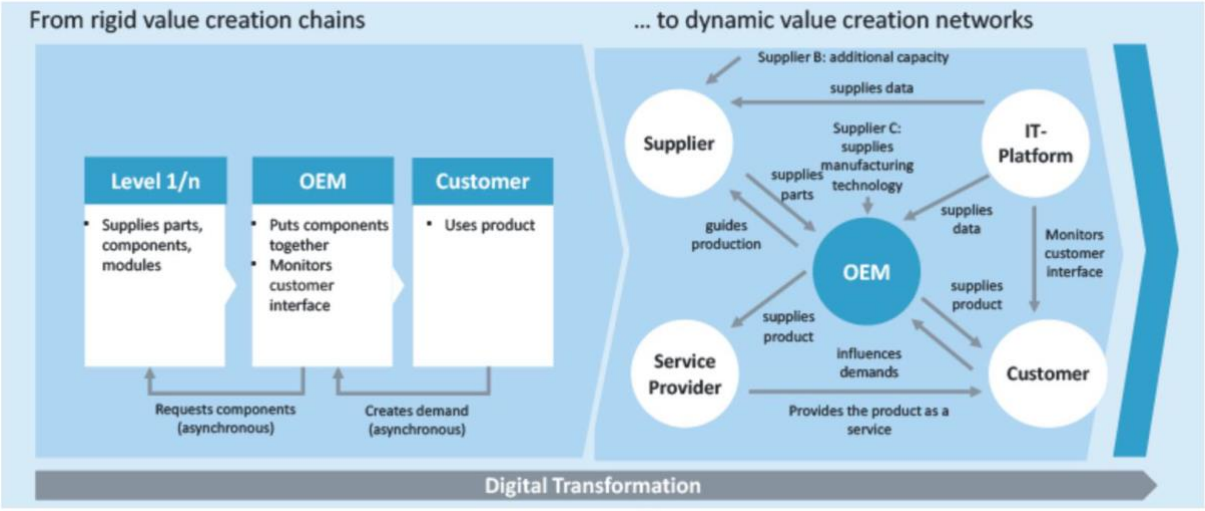


Figure 3—Toward a dynamic supply chain[19]

Current tensions and uncertainties surrounding supply chain performance

Uncertainty is now an integral part of our societies and must therefore be seen as an opportunity to rethink processes and each actor's role within the supply chain. The risks inherent in a supply chain must first be identified and then managed appropriately to prevent any potential disruption. Risks are numerous, vary in nature, and can potentially affect the entire supply chain. The following risks have been identified in the current environment:

- **The environment:** Risks associated with a climate event, such as flooding or drought, or with access to resources. As natural resources become increasingly scarce, alternative sourcing arrangements are sometimes necessary. Similarly, the shortage of electronic components has placed many supply chains under strain, exposing their weaknesses, particularly in sourcing.
- **Health and geopolitical crises,** including COVID-19, the war in Ukraine, and the Red Sea crisis. These crises often have global repercussions, such as border closures, which in turn affect long supply chains through raw-material shortages or longer maritime transportation times.
- **The supply chain's network of actors:** Risks associated with collaboration with other companies, particularly suppliers and the diversity of supply sources, as well as risks associated with information sharing, such as data theft (McKinnon, 2014).
- **The dual shortage of skills and labor:** First, there is a shortage of workers in low-skilled jobs, such as truck driving. In Europe, 10% of positions were unfilled in 2023[20]. Particularly difficult working conditions—several days away from home and reception conditions at delivery sites—a poor occupational image, and unattractive pay are the main reasons for the lack of applicants[21]. Second, a skills shortage is also emerging in jobs related to new technologies. The ongoing technological

[19] https://blog.seeburger.com/why-your-supply-chain-needs-real-time-data/

[20] https://www.transportexpress.fr/fr/actualites/transport-routier-tendances

[21] https://www.enjeuxlogistiques.com/etude-difficultes-de-recrutement-le-fret-routier-en-premiere-ligne/

transition requires new skills that existing teams do not necessarily possess[22]. Companies must therefore often train their teams internally[23].

The identified risks are then ranked by probability of occurrence—could the risk actually materialize?—and criticality—what would its impact on the supply chain be? In response, companies take measures to strengthen supply chain resilience, whether through improvements or complete transformation[24]. This is all the more important because the ability to manage risks differentiates a company from its competitors and can even provide a competitive advantage[25].

In the face of the multiple risks mentioned above, supply chains must adapt. Alongside the economic performance emphasized earlier, **organizational performance, through supply chain resilience and reliability, is becoming an essential criterion** (Hollnagel et al., 2009). This criterion involves a change in the time horizon of supply chain management, from the short term for economic performance to the long term for organizational performance, even as the environment and the market are constantly changing.

Reshoring efforts led primarily by SMEs

In this context, businesses are increasingly considering **reshoring**. Reshoring is defined as "a voluntary corporate strategy involving the partial or total relocation of production, whether internal or external, away from the home country to meet local, regional, or global demand" (Fratocchi et al., 2014, p.56).

Reshoring often responds to consumer demand for greener products (Heydari et al., 2021) manufactured locally [the "made-in effect," Barbieri et al., 2018]. The decision to reshore therefore requires the supply chain to be reorganized at several levels: identifying new suppliers, reorganizing the transportation and distribution network, and so on. The France Relance recovery plan, launched by the French government in 2020 to encourage reshoring[26], enabled ninety reshoring projects in 2021, primarily led by very small businesses and SMEs. Large companies, however, do not yet appear to have implemented large-scale reshoring projects involving several thousand salaried jobs, while the energy crisis, and particularly soaring energy prices, may hinder such projects.

Supply chain sustainability objectives and supplier monitoring

Numerous scandals, such as the collapse of a textile workshop in Bangladesh and the 2013 horsemeat lasagna scandal, have called into question the responsibility and practices of all supply chain actors.

Consumers, particularly millennials, demand greater transparency about product origins, supply chain operations, and the practices of the companies involved, including respect for human rights, environmental and social responsibility, and efforts to combat corruption[27]. Increasingly, NGOs monitor and standardize sustainable practices in existing supply chains. Ethical Consumer[28], for example, identifies companies adopting ethical practices to inform consumers. RAINFOREST and Fairtrade have established now-recognized certifications for sustainable supply chain practices[29]. Other standards also encourage changes in practice,

[22] https://www.lesechos.fr/idees-debats/leadership-management/industrie-40-alerte-sur-les-competences-1245202

[23] https://www.la-fabrique.fr/fr/publication/organisation-et-competences-dans-lusine-du-futur-2/

[24] https://www.wtwco.com/fr-fr/insights/2023/02/rapport-enquete-risques-supply-chain-2023

[25] https://hbr.org/2007/08/building-a-resilient-supply-ch

[26] https://www.europe1.fr/economie/relocalisation-pres-de-155-entreprises-sont-revenues-en-france-grace-au-plan-france-relance-4150991#:~:text=155%20relocalisations%20ont%20eu%20lieu,France%20rien%20qu%27en%202021.

[27] https://scw-mag.com/news/top-10-supply-chain-ethics-to-follow/

[28] https://www.ethicalconsumer.org/

[29] https://www.fairtrade.org.uk/for-business/fairtrade-sourcing/

including ISO 20400, introduced in 2017 for sustainable procurement[30], and the European Commission's Product Environmental Footprint method for calculating environmental performance[31].

In response to these multiple institutional and societal pressures, manufacturers at the center of supply chains and certain scandals have reassessed their supply chains and announced sustainability objectives. In 2020, according to an MIT report[32], 49% of companies reported having set sustainability objectives for their supply chains. A sustainable supply chain thus takes account of "the economic, environmental, and social objectives of sustainable development, derived from the requirements of customers and stakeholders" (translated from Seuring and Muller, 2008).

Progress is therefore evident, with a better understanding of sustainability issues in the face of climate change and of practices to reduce supply chains' environmental impact (see the CDP 2019 report). For example, more and more manufacturers and their suppliers are joining the Carbon Disclosure Project[33] to measure their supply chains' carbon emissions in concrete terms.

However, certain limitations are also apparent. A study of nine multinationals highlights two major limitations (Villena & Gioia, 2020). First, monitoring of second-tier suppliers remains limited, and economic pressures on these suppliers, most often based in developing countries, lead them to favor unsustainable practices. Second, the study shows that supplier selection is based primarily on customer-related efficiency and economic performance—"profit"—at the expense of environmental and social issues—"people and planet" in Villena & Gioia, 2020.

Moreover, when sustainability issues are incorporated into supply chains, companies prioritize social and ethical dimensions concerning workers, while environmental issues involving natural-resource management, waste, and carbon emissions receive secondary attention (MIT report, 2020[34]). Although a sustainable supply chain requires sustainable resource management—energy, water, raw materials, and so on—and the use of renewable energy, implementation is still developing.

The development of circular supply chains through diverse approaches

Many existing supply chain initiatives fall wholly or partly within the circular economy: eco-innovation initiatives involving buyers and suppliers, management of return flows, and so on. Waste management, for example, already developed within conventional supply chains, is often an element that companies highlight. Seventy percent of companies report investing in circular economies that reduce waste through reuse and recycling[35].

However, practices related to the circular economy are heterogeneous and encompass several configurations whose synergies with sustainability challenges vary:

- Full synergy involves a complete reconfiguration of the supply chain, incorporating new activities and new actors.
- Partial synergy occurs when the circular economy is one of several ways to implement sustainable practices, such as environmentally oriented product design, or ecodesign, green human resource

[30] https://www.hellocarbo.com/blog/reduire/iso-20400/#:~:text=La%20norme%20ISO%2020400%20incite,cette%20d%C3%A9marche%20d%27achats%20responsables.

[31] https://green-business.ec.europa.eu/environmental-footprint-methods_en

[32] 35% of companies have not defined any sustainability objectives for their supply chains (Massachusetts Institute of Technology, "State of Supply Chain Sustainability" report, 2020).

[33] https://www.cdp.net/en/supply-chain

[34] Massachusetts Institute of Technology, "State of Supply Chain Sustainability" report, 2020.

[35] Économie circulaire (external link to ibm.com) : l'avenir de la chaîne d'approvisionnement, Supply Chain Digital, May 17, 2020

management, or advanced waste management. These practices are then isolated responses to specific supply chain needs, without necessarily reflecting an integrated approach or a desire to develop a fully circular supply chain.

Sustainable supply chains must therefore be distinguished from circular supply chains according to the degree of integration between the two (Interview A.E.). Sustainable practices can be introduced within supply chains without challenging their linear configuration. For example, Nutella sources 100% traceable palm oil[36], certified by an external organization, the RSPO[37]—Roundtable on Sustainable Palm Oil. At the same time, circular supply chains may be established without taking responsibility for their environmental impacts, for example when they extend across several countries and/or continents. Nevertheless, some companies, such as Patagonia, adopt integrated circular and sustainable supply chain models.

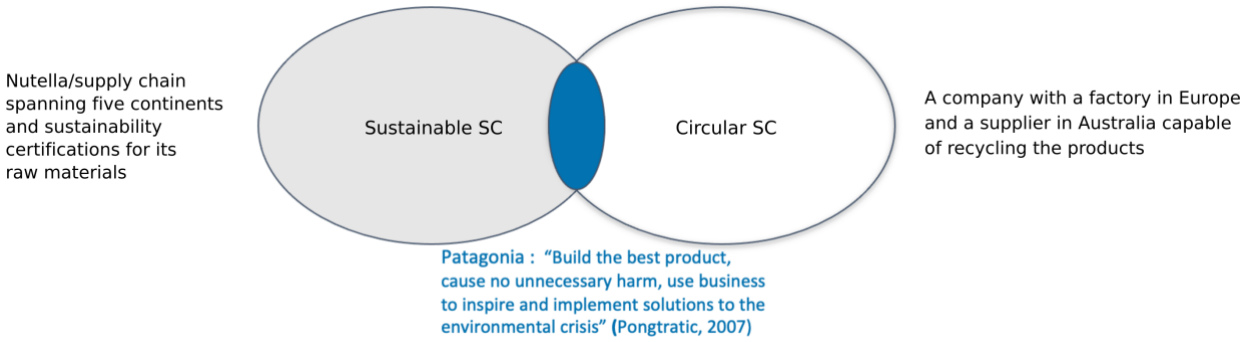


Figure 4—Synergies and distinctions between sustainable and circular supply chains

Circular supply chains rely on new technologies. Circularity requires greater sharing of qualitative, reliable information about complex flows among a multitude of actors, with traceability crucial for raw materials and reused products because of safety standards[38]. In this context, new technologies play an essential role by facilitating the sharing of reliable, real-time information. Integrated sensors, real-time data analysis, and devices such as the Internet of Things (IoT) allow products to be tracked throughout the supply chain while optimizing resources and reducing waste[39].

3. Foresight exploration

3.1. Structural trends

Long supply chains involving numerous actors. In connection with globalization, supply chains continue to involve numerous actors—second-tier suppliers and B2B2C distribution chains containing several intermediaries and customers—spread across the globe. The development of new activities, such as waste management, brings in additional actors, making the supply chain even more complex. Recent crises, such as COVID-19, have exposed supply chain vulnerabilities, particularly in chains operating globally. Nevertheless, supply chains remain long and involve multiple actors despite changes in their configuration and the emergence of circular economy practices. For example, reshoring production does not necessarily involve changing suppliers located on another continent. Meanwhile, in a globalized context, customers are now located worldwide, so the supply chain is also lengthening downstream through the distribution of finished products.

[36] https://www.nutella.com/int/fr/coulisses-nutella/nos-engagements-durables/huile-de-palme#:~:text=L%27huile%20de%20palme%20que,)%20suivi%20de%20l%27Indon%C3%A9sie.

[37] https://rspo.org/

[38] https://institut-economie-circulaire.fr/wp-content/uploads/2023/04/Plaidoyer-Supply-Chain-Circulaire-mars-2023.pdf

[39] https://www.linkedin.com/pulse/embracing-sustainability-circular-supply-chain-model-role-sharma/

A dominant actor, known as the focal firm, exerts significant influence within supply chains, where economic and financial performance remains the main criterion of effectiveness. The focal firm, very often the producer or distributor, frequently carries more weight than other actors and influences the practices implemented within the supply chain. The evolution of a linear supply chain into a more open system, with the introduction of new sustainable and/or circular initiatives, is therefore often led by a focal firm (Tite, 2020). As an innovator, the focal firm will be the first to implement new practices, which gradually spread to other supply chain partners.

Synergies between Industry 4.0 and supply chain circularity (Kumar et al., 2023; Ozkan-Ozen et al., 2020). The integration of technological advances, particularly new technologies to improve supply chain efficiency, is a structural trend. Initially used mainly in production in connection with the deployment of Industry 4.0, new technologies such as blockchain strengthen product traceability within supply chains and thus the confidence of all stakeholders, including consumers. The easy, real-time access to reliable information enabled by new technologies also facilitates the implementation of new circular economy practices.

The institutionalization of the three R's—reduce, reuse, and recycle—and its impact on supply chain management. These objectives of reduction, reuse, and recycling are now incorporated into national waste-management policies. Such state intervention is neither recent nor unique to France, as illustrated by the incorporation of recycling into Japanese legislation in 1991 and the adoption of Germany's Waste Disposal Act in 1976 (Ghisellini et al. 2016). At the European Union level, a directive on waste management and material reuse was introduced in 2008. These institutional pressures to promote more effective closed-loop management of the three R's are intensifying, leading to a growing role for local authorities and the emergence of new supply chain actors.

The repercussions of geopolitical conflicts persist, inexorably affecting supply chains. Violent conflicts arising from war and terrorism will continue in the coming years, despite all our efforts to prevent them[40]. Supply chain resilience should remain a priority.

3.2. Uncertainties

An uncertain degree of supply chain reconfiguration toward "strong" sustainable models and their synergies with the circular economy[41].

Although many practices exist and are implemented within supply chains, they remain highly heterogeneous. Corporate sustainability initiatives often focus primarily on social issues, while the integration of environmental aspects concerns only one pillar of the circular economy, such as sustainable sourcing or recycling. This fragmented approach raises questions about companies' ability to adopt a holistic perspective that promotes synergy between sustainability and circularity by encompassing all aspects of the circular economy. Some experts criticize policies for providing insufficient incentives for comprehensive supply chain transformation[42].

Supply chain resilience is necessary, but in what form?

For a long time, the engineering approach to resilience prevailed in supply chains (Wieland and Durach, 2021). This approach considers resilience from an engineering perspective, aiming for supply chain stability—the ability to "bounce back" after a disruption—and viewing the chain as a closed, planned, and controlled system. With supply chains becoming increasingly complex, engineering resilience is gradually being

[40] https://www.iss.europa.eu/sites/default/files/EUISSFiles/ESPAS_Report2019_FR.pdf

[41] The concept of strong sustainability, originating in heterodox economics, challenges the possibility of substitution between natural resources and human activities and refocuses the transition process on environmental issues, in synergy with social and economic dimensions.

[42] https://www.actu-environnement.com/ae/news/etude-supply-chain-circulaire-cabinet-citwell-prodURable-43317.php4

challenged in favor of social-ecological resilience[43], which incorporates human decision-makers and social interactions alongside technical aspects. The supply chain is then interpreted as a fluid, open system interacting with the rest of the world, whose objective is adaptation and transformation rather than stability. The uncertainty lies in companies' ability to shift toward social-ecological resilience, which requires innovative practices. The capacity for change, in terms of exploring possible options, and the degree of flexibility or rigidity in response to environmental changes remain crucial in the pursuit of social-ecological resilience.

Limited recycled resources?

There is also uncertainty about companies' ability to meet consumer demand for recycled products. The functional economy, one of the pillars of the circular economy, prioritizes product use over product sales. Consequently, purchases of finished products will decline substantially as consumers prefer to buy a service rather than a product (Alicke et al.,2022). This reduction in finished-product consumption will also affect the entire circular supply chain, which may then struggle to access recycled raw materials. Finished products from circular supply chains would consequently become harder to find. Moreover, most materials cannot be recycled indefinitely. Paper, for example, can only be recycled three to six times[44]. Circular supply chains may therefore have to source virgin raw materials to compensate for the lack of recycled raw materials.

The technical challenge of the circular economy at scale.

Plastic recycling remains a real technical challenge. There are dozens of different polymers, each with its own characteristics—hard or soft, transparent or opaque, suitable for food contact, and so on—and each therefore requiring a specific recycling treatment. Another difficulty is that these different plastics are very often mixed with other materials, complicating the production of a recycled raw material equivalent to a virgin one[45]. In this context, scaling up is often problematic, as illustrated by Scale Vision[46], a French company offering a material called "Scalite," made from recycled fish scales and suitable for cladding, furniture, decorative accessories, and other uses. After five years of development, the company closed in 2023 because it lacked real market outlets and, above all, local supplies: It had to source fish scales from . . . Asia[47]. The circular economy therefore cannot become established sustainably and on a large scale unless the techniques and technologies required for its new activities are mastered. Some therefore raise the possibility of a low-tech circular economy[48], an approach that simplifies products as much as possible from the design stage, thereby making recycling easier.

3.3. Controversies

The stance taken by dominant actors—the focal firm—and the sharing of responsibilities within the supply chain are subjects of debate.

[43] https://fr.wikipedia.org/wiki/R%C3%A9silience_de_la_cha%C3%AEne_d%E2%80%99approvisionnement

[44] https://books.openedition.org/editionscnrs/10730?lang=fr

[45] https://www.latribune.fr/entreprises-finance/industrie/energie-environnement/quels-leviers-pour-l-economie-circulaire-773800.html

[46] https://www.youtube.com/watch?v=HphHkLbkzhw

[47] https://www.ladn.eu/ladn-transition/monde-fabrique-en-dechets/#:~:text=En%202018%2C%20l%27Union%20europ%C3%A9enne,application%20de%20la%20loi%20AGEC.

[48] https://goodwill-management.com/economie-circulaire-et-low-tech/

In current sustainable supply chains, some large focal firms tend to disavow responsibility for negative impacts[49], for example in the agrifood industry. Palm oil producers are criticized for their environmentally harmful practices, as are end consumers who, despite being aware of environmental problems, continue to consume products that are not environmentally friendly, as in the case of Nutella. Despite marketing campaigns highlighting their support for, or initiatives involving, small local producers—a paternalistic approach, or "collaborative washing"—agrifood multinationals distance themselves from their suppliers when their environmental impact is challenged (Carmagnac et al., 2022).

Negative environmental impacts of supply chain circularity.

The positive impact of a circular supply chain on the environment and society remains controversial[50]. Some argue that implementing circular practices does not reduce environmental impact for a simple reason: the rebound effect. Under the Jevons paradox, as technological improvements increase the efficiency with which a resource is used, total consumption of that resource may increase rather than decrease[51]. For example, when recycled products from circular supply chains are not adequate substitutes for conventional finished products, they lead to increased environmental impact. Greater consumption and use also trigger this rebound effect. In the United States, researchers have shown that smartphone reuse generated a rebound effect that canceled out 30% to 45% of the expected emissions savings (Makov & Font Vivanco, 2018). These rebound effects stem from the absence of a holistic, systemic approach to the supply chain.

3.4. Seeds of change and weak signals

An increasingly strategic and integrated role for NGOs within supply chains.

NGOs have often acted as whistleblowers concerning supply chain scandals. Amnesty International, for example, raised the alarm about cobalt from mines using child labor being used by major electronics brands such as Apple, Samsung, and Sony[52]. However, NGOs' role is evolving from that of an external actor denouncing supply chain practices after the fact to that of a partner intervening beforehand and even participating in supply chain design. Many NGOs are involved in certification processes to improve transparency in practices and product traceability, increasing supply chains' legitimacy (Léon-Bravo et al., 2022). Some experts believe that social and environmental NGOs also have a major role to play alongside supply chain actors in efforts to transition supply chains toward sustainability (Carmagnac et al., 2022).

A supply chain can be both circular and sustainable.

More and more companies seek to develop supply chains that are both circular and sustainable. Tetra Pak, for example, aims to expand the collection of used packaging in order to use recycled materials to produce recyclable packaging[53]. At the same time, the company is also designing new processing and packaging equipment that can be maintained, refurbished,

50https://www.polytechnique-insights.com/tribunes/economie/5-idees-pour-demystifer-leconomie-circulaire/#note-11

51 https://fr.wikipedia.org/wiki/Paradoxe_de_Jevons

[49] https://www.xerficanal.com/iqsog/emission/Valentina-Carbone-Grands-defis-comment-les-grands-acteurs-organisent-leurs-irresponsabilites_3751584.html

[50] https://www.polytechnique-insights.com/tribunes/economie/5-idees-pour-demystifer-leconomie-circulaire/#note-11

[51] https://fr.wikipedia.org/wiki/Paradoxe_de_Jevons

[52] https://www.amnesty.org/fr/latest/news/2016/01/child-labour-behind-smart-phone-and-electric-car-batteries/

[53] https://www.tetrapak.com/fr-fr/sustainability/focus-areas/circularity-and-recycling/approach-recycling-and-circularity

52 https://www.amnesty.org/fr/latest/news/2016/01/child-labour-behind-smart-phone-and-electric-car-batteries/

53https://www.tetrapak.com/fr-fr/sustainability/focus-areas/circularity-and-recycling/approach-recycling-and-circularity

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and repaired to extend its lifespan. The Teemill platform[54] is revolutionizing the textile industry by offering a circular supply chain to produce T-shirts for startups or designers, all designed to be returned and recycled when worn out. Beyond circular and sustainable T-shirt production, Teemill enables anyone with internet access to participate in and cocreate the future of fashion while protecting the planet.

3.5. Disruptions

Economic performance is no longer enough: Toward different measures of supply chain performance.

In a disruptive shift, companies could be led to reassess their KPIs, prioritizing environmental criteria that ensure continuity of raw-material supply without disruption and moving beyond the controversy over circularity's negative environmental effects. In this shift, companies primarily measure environmental performance using the Product Environmental Footprint method[55] mentioned earlier (see 2.2). Drawing on various expert organizations, supply chain effectiveness is measured in terms of resource management and ADEME's seven pillars of the circular economy[56].

Second-tier suppliers and consumers become important supply chain decision-makers.

Moving beyond the focal firm's educational and paternalistic approach, the supply chain relies on a horizontal decision-making process in which all actors involved can influence its strategic decisions.

Short, local supply chains become the dominant model.

The questioning of globalization brings a break with long supply chains under growing economic, social, and political pressure for short distribution channels and local chains. This trend toward reshoring supply chains, which began in recent years, becomes a dominant model also adopted by large companies. PwC, for example, mapped procurement spending and associated import rates in four industrial sectors—health care and pharmaceuticals, agrifood, electronics, and process and assembly industries—to identify fifty-eight product and service categories with significant reshoring potential, representing 115 billion in imports[57]. If production of 20% of these fifty-eight categories were reshored to France in the near future, this would represent approximately 75,000 direct jobs and 220,000 indirect jobs.

The end of product returns because of an inability to establish reverse logistics.

Companies are unable to manage effectively the exponential increase in returns of products purchased online[58]. Currently, discarding or incinerating returned items costs less than putting them back into circulation[59]. Some retailers, including Zara, H&M, and Uniqlo, have resumed charging for this service,

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[54] https://teemill.com/

[55] https://green-business.ec.europa.eu/environmental-footprint-methods_en

[56] 1/responsible extraction, resource development, and procurement, 2/ecodesign 3/industrial and territorial ecology 4/functional economy 5/responsible consumption 6/extending the duration of use 7/recycling

[57] https://www.pwc.fr/fr/espace-presse/communiques-de-presse/2020/juillet/etude-sur-la-relocalisation-des-achats-strategiques.html

[58] https://www.laveniradubon.fr/fetes-2022/la-gratuite-des-retours-est-elle-un-desastre-ecologique

[59] https://www.theguardian.com/fashion/2022/apr/10/shein-the-unacceptable-face-of-throwaway-fast-fashion?utm_term=6253a7c53fe63656fce3a3b7ca3ab3e2&utm_campaign=GuardianTodayUK&utm_source=esp&utm_medium=Email&CMP=GTUK_email

although customers strongly favor free returns[60]. Some see an approaching end to free returns[61], because they generate considerable costs for companies. A Narvar report published at the beginning of the year and covered by the BBC estimates that retailers spend approximately $33 per return, including shipping, packaging, the item's loss of value, labor, and missed sales opportunities[62]. Narvar is a US company specializing in returns management. Faced with this reality and the ecological disaster associated with returns, some companies could decide to stop offering customers the option of returning products and thus no longer have to manage returns of online purchases.

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[60] https://www.ecommercemag.fr/Thematique/retail-1220/veille-tribune-2169/Breves/E-commerce-la-fin-des-retours-gratuits-au-profit-du-387484.htm

[61] https://www.sendcloud.fr/tour-dhorizon-retours-e-commerce/

[62] https://www.ecommercemag.fr/Thematique/retail-1220/veille-tribune-2169/Breves/E-commerce-la-fin-des-retours-gratuits-au-profit-du-387484.htm

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Secondary data from the reports and websites listed in the footnotes.