

# Sustainable and Resilient Supply Chains: Insights from Empirical Evidence

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## **Abstract**

The importance of being both sustainable and resilient in a supply chain is increasingly fundamental, and there is initial evidence that sustainability and resilience practices influence each other. Yet, there is still little research and empirical evidence on the synergies and trade-offs of these practices. This study aims at unveiling the impacts, synergies and trade-offs that result from the implementation of supply chain sustainability and resilience practices. Starting from a literature review, six semi-structured interviews have been carried out with focal firms belonging to manufacturing supply chains. The preliminary results show the presence of synergies among practices.

**Keywords:** Sustainability; Resilience; Supply Chain.

## **Introduction**

Sustainability and resilience are often cited among the two fastest-growing research streams in the supply chain field (Swanson et al., 2018). Indeed, they are both pivotal for the survival of the supply chains: on the one hand, stakeholders and regulators require supply chains to improve their sustainability, along the three economic, environmental and social pillars (Ahi and Searcy, 2013; Meixell and Luoma, 2015); on the other hand, supply chains are required to ensure business continuity and build resilience (A. Ali et al., 2017).

Supply chain sustainability and resilience have been studied mostly separately so far, but increasing evidence shows deep mutual influence between the two concepts (Fahimnia et al., 2019). In particular, there is initial evidence that there might be synergies and trade-offs between the practices of sustainability and resilience (Jabbarzadeh et al.,

2018). However, little is still known on how to develop these synergies and how to minimize trade-offs, and more in additional general research should be devoted to developing this nascent research area.

This paper aims at exploring the presence of synergies and trade-offs among the practices of supply chain sustainability and supply chain resilience. For this purpose, an initial literature review has been performed to retrieve the contributions discussing this topic, in particular focusing on the impacts of the implementation of the practices. The results from the literature review have been enriched with an exploratory empirical analysis with six focal firms belonging to different industrial sectors. Although additional research on the topic is called for, this initial analysis brings significant contributions.

## **Literature review**

The literature has been searched in order to retrieve the relevant contributions discussing synergies and trade-offs from sustainability and resilience practices. Studies on the impact stemming from the implementation of the practices have also been included, since there is still a paucity of papers on the development of synergies and trade-offs.

Concerning sustainability, the prominent role of supply chains is widely acknowledged (Kennedy and Kundu, 2017). Although some practices are considered more internal management, most of these have repercussions on the entire supply chain (Silva et al., 2019), and a high degree of collaboration is usually called for (Govindan et al., 2014). Implementing sustainability practices is often connected to improved economic and environmental performance (Ahmed et al., 2019; Dey et al., 2020). In particular, operational performance improves (Çankaya and Sezen, 2019), costs for non-compliance reduce (Choi et al., 2017), product quality improves (Pullman et al., 2010). Besides, sustainability practices bring lower waste being produced (Golicic et al., 2017), lower hazard of materials and waste (Assumpção et al., 2019), material use decreases (Kennedy and Kundu, 2017), emissions are reduced (Migdadi, 2019). The social pillar of sustainability is also enhanced (Zaid et al., 2019).

As for sustainability, resilience practices have a strong supply chain connotation (A. Ali et al., 2017). Implementing resilience in supply chains is found to improve the supply chain competitiveness (Azevedo et al., 2012), lower performance volatility (Pettit et al., 2013), reduce the impact of unpredictable circumstances (I. Ali et al., 2017) and ensure fast recovery (Rashid et al., 2014).

Instead, the number of studies analysing the impact of sustainability practices on resilience and vice versa is drastically lower. Some authors pointed out that sustainability practices may reduce the supply chain risk, as less hazardous substances are used and health-related issues are avoided in the first place (Gouda and Saranga, 2018). Resilience practices are sometimes characterised in terms of impact on the economic pillar: a reduction in supply chain costs is usually expected as costs for disruptions are reduced (DiMase et al., 2016), and managing risk may also benefit the social pillar (Miemczyk and Luzzini, 2019). However, the outcome of resilience practices on costs is still debated (Rajesh, 2018). Overall, more research on the mutual influence of sustainability and resilience practices should be developed.

The literature is even scunter when considering the development of synergies and trade-offs. The literature seems to suggest that sustainability has a synergic effect on supply chain risk, as many sources of risk are eliminated (Gouda and Saranga, 2018; Syed et al., 2019). Collaboration practices appear to be positive for both sustainability and resilience, by fostering visibility and transparency (Bag et al., 2018). Supply chain readiness appears to be linked to both improved sustainability (DiMase et al., 2016) – especially in terms of costs – and resilience (Scholten et al., 2014).

Instead, developing flexibility for resilience seems to be in trade-off with sustainability. In this sense, an excessive focus on the efficiency of resources may be beneficial for sustainability but detrimental for resilience (Carvalho et al., 2012).

Overall, a more systemic approach to the identification of synergies and trade-offs should be developed, and complemented with empirical evidence from firms and supply chains.

### Research methods

For the purpose of this study, a model to read the results of the empirical application has been built from the literature. A list of sustainability practices has been adapted from the one by (Assumpção et al., 2019; Zhu et al., 2008), as one of the most cited in the literature. For the resilience practices, a list of practices has been adapted from (Awaysheh and Klassen, 2010; Carvalho et al., 2011; Chowdhury and Quaddus, 2017; Dabhilkar et al., 2016).

The impacts of the practices have been divided into several components. As for sustainability, the impacts were analysed in terms of the traditional Triple Bottom Line (TBL) (Cagno et al., 2019); for resilience, the impacts were divided into three components (Risk reduction, Impact mitigation and Learning and Growth), in line with previous literature (Colicchia et al., 2010).

The empirical investigation has been performed by means of semi-structured interviews. Multiple firms were interviewed to improve the robustness of results and external validity (Barratt et al., 2011; Voss et al., 2002). Six firms were interviewed, of different manufacturing sectors, size location, awareness level (Baškarada, 2014). The research focused on the manufacturing sector as one of the most impactful on the environment (Acerbi and Taisch, 2020) and one of the most important for European economy (Eurostat, 2020). Therefore, manufacturing firms have traditionally been pushed to improve their sustainability performance and to ensure business continuity. This made them particularly suitable for the present study.

The interviews have been conducted with the focal firm of different supply chains, as per previous studies (Govindan et al., 2020). This choice was led by the fact that the focal firm is the one able to influence other supply chain partners in their behaviours (Cheung and Rowlinson, 2011; Marshall et al., 2015; Michelsen, 2007) and that is usually held responsible for unsustainable or un-resilient outcomes of the supply chain (Tuni et al., 2020). The focal firm has been defined as “a firm that rules or governs the supply chain, provides the direct contact to the customer, and designs the product” (Masi et al., 2018). The supply chain focus has been kept by analysing the impacts along the entire supply chain, and for this reason, the supply chain managers of the focal firms have been interviewed (Dooley, 2002).

### Results and discussion

Table 1 reports the main characteristics of the interviewed firms, while Table 2 reports the results obtained from the interviews.

*Table 1 – Characteristics of the interviewed firms*

Firm	Size	Sector	Products	Production volume	Reference market	Supply chain
A	1,700	Food industry	Festivity products; snacks and cookies	110,000 ton/year	85% Italy 15% Export	<ul style="list-style-type: none"> <li>• Reference suppliers with dominant position; alternative suppliers.</li> <li>• long-term partnerships.</li> </ul>

B	12,000	Boat industry	Engines and motor components	250,200 units/year	Global coverage	<ul style="list-style-type: none"> <li>• Global suppliers</li> <li>• Internal production for most parts</li> <li>• B2B clients</li> </ul>
C	8,000	Electric appliances industry	Coffee machines, electrical appliances, home appliances	35 million pieces/year	Global coverage	<ul style="list-style-type: none"> <li>• Vertical integration</li> <li>• More radical use of e-commerce downstream (10% of total sales)</li> </ul>
D	72	Space industry	Small scale satellites	2 units/year	Global coverage	<ul style="list-style-type: none"> <li>• Small firms downstream</li> <li>• Strong collaboration</li> </ul>
E	55	Apparel industry	Jackets and coats	600,000 pieces/year	50% Italy 50% Europa/USA/Canada/Asia/PAC	<ul style="list-style-type: none"> <li>• Small and selected suppliers</li> <li>• B2B and B2C clients</li> </ul>
F	1,820	Soft drinks and water industry	Soft drinks	1.4 billion litres/year	Mainly Italy	<ul style="list-style-type: none"> <li>• International suppliers for raw materials</li> <li>• Smaller suppliers for niche markets</li> <li>• Clients: GDO and HORECA</li> </ul>

As appreciable from Table 2, most of the practices implemented belong to the sustainability sphere. This could be explained by a higher and longer developed awareness of firms on the topic. However, while sustainability practices usually require internal and external awareness to be implemented, firms seem to understand the importance of resilience practices more intuitively.

The most implemented practices resulted to be *greening of logistics*, *use of certifications* and *eco-design*. According to the results obtained, green logistics shows a synergic effect between sustainability and resilience. Indeed, it has a positive outcome on the three pillars of the TBL, especially in terms of lower emissions, lower use of resources for instance for packaging. This is in line with previous literature (Çankaya and Sezen, 2019; Islam et al., 2017; Kitsis and Chen, 2019). At the same time, the risk seems to be reduced and the impact of disruptions is diminished thanks to better control on material flows. It also allowed the firms to rethink their networks optimizing it.

Certifications also seem to suggest synergies between sustainability and resilience. Despite their high initial cost, firms reported positive impacts on the TBL. They also promote a culture of continuous improvement inside the supply chain, which also enhances resilience, as in (I. Ali et al., 2017).

*Table 2 – Practices implemented by the firms and the impact observed (Red cells correspond to a negative impact; Yellow cells to a neutral or uncertain impact; Green cells to a positive impact)*

Practices		Sustainability			Resilience		
		Ec	Soc	Env	Risk	Imp	L&G
Sustainability practices	<b>Cat. 1: Internal Environmental Management (IEM)</b>						
	Environmental management systems - ISO 14001 certification	A	A	A		A	A
	Use of Ecolabels, taking into account environmental criteria	F		F			F
	Green Manufacturing			B F			F
	<b>Cat. 2: Green Purchasing (GP)</b>						
	Local sourcing	A		A	A		
	<b>Cat. 3: Cooperation with customers (CC)</b>						
	<b>Cat. 4: Ecodesign (ECD)</b>						
	Design products to reduce the consumption of raw materials and energy	F		B F	F		F
	Design products for reuse, recycling, recovery of materials and components	C		C		C	
	Design products to avoid or reduce the use of hazardous products in the manufacturing process	C	C	C	C		
	Design product for environmentally friendly objectives	E	E	E			
	<b>Cat. 5: Investment Recovery (IR)</b>						
	<b>Cat. 6: Environmental Innovation (EI)</b>						
	<b>Cat. 7: Environmental Performance (EP)</b>						
	Third party certification of environmental practices	E	E	E			E
	Sustainability reporting	A	A	A		A	A
	<b>Cat. 8: Green Compliance (GC)</b>						
	<b>Cat. 9: Green Marketing (GM)</b>						
	<b>Cat. 10: Suppliers Relationship (SR)</b>						
	Require Supplier Certification		F	F			
	Collaborate with suppliers	D	D		D		
	<b>Cat. 11: Logistics (RL)</b>						
Green Logistics	A B C F	A	A B C F	B B F	A B F	B C F	
<b>Cat. 12: Social practices</b>							
Philanthropy and social welfare	B	B		B			
Employee welfare	D	D		D	D	D	
		F				F	
Resilience practices	<b>Cat 1: Supply chain Disaster readiness --&gt; risk management</b>						
	Forecasting			B		B	
	<b>Cat 2: Flexibility</b>						

	Flexible supply base	A	A	A	A	A	A
		F	F		F	F	
	<b>Cat 3: Reserve capacity</b>						
	<b>Cat 4: Integration</b>						
	Vertical Integration	B		B	B		
		C		C		C	
	Sharing information with supply chain partners	B				B	
	<b>Cat 5: Efficiency</b>						
	<b>Cat 6: Market strength</b>						
	<b>Cat 7: Financial strength</b>						
	<b>Cat 8: Response</b>						
	<b>Cat 9: Recovery</b>						
	<b>Cat 10: Node density</b>						
	<b>Cat 11: Complexity</b>						
<b>Cat 12: Criticality</b>							
<b>Cat 13: Agility practices</b>							

Finally, eco-design seems to allow both enhanced sustainability and resilience despite its unclear impact on costs. Firms reported a negative impact in terms of costs and effort required, but the positive outcomes on the environment and communities outweigh this. Extant literature suggests that eco-design might worsen the economic performance of supply chains (Green et al., 2012). Still, a positive impact is found on customers and employees, especially if toxic and hazardous substances are eliminated (Abdullah et al., 2019). Firms also pointed out that investing in eco-design reduces the risk of disruptions and improves the learning process.

Among the other practices mentioned, investing in social welfare has a positive impact on the social pillar of sustainability, while the impact on resilience appears controversial. Firm C reported increased risk from this practice, while Firm A a reduced one. More research should be conducted to clarify this point further. Green manufacturing was reported to entail positive impacts on both sustainability and resilience. Indeed, besides reducing material use, emissions, pollution, waste, and increased competitiveness and productivity, firms also reported increased attention to processes and learning.

Local sourcing emerged as both sustainable and resilient, as it ensures lower emissions from transport and more equal distribution of economic flows. Closer suppliers also allow for better coordination of the supply chain, bringing several benefits (Mitra and Datta, 2014).

Collaboration with suppliers allowed having lower costs, lower material use and less hazardous materials, while the impact on the risk component of resilience is neutral. However, this practice is expected to reduce the risk associated with supply chain partners (Rajesh, 2020; Zineb et al., 2017). Instead, while the literature usually mentions that flexibility practices may enhance resilience but lower sustainability (Azevedo et al., 2012), the interviewees reported a positive impact on the three pillars of the TBL and resilience. This might be a consequence of the careful planning of the supply chain performed by Firms A and F.

## Conclusions

This study explored the mutual influence that sustainable and resilient practices have. Overall, the interviews confirmed that sustainability and resilience should be developed together to fully exploit their benefits. In particular, embedding resilience into sustainable supply chain thinking might be the cultural change necessary to foster the adoption of more sustainable practices among practitioners.

Although more research should be devoted to better understand how to exploit synergies and trade-offs of practices, this study provides a first understanding of the mutual impact of sustainability and resilience practices. Firstly, the link between practices and their impact in terms of sustainability and resilience will help expand the discussion in the academic literature. Secondly, it could be useful to practitioners who will know in advance what to expect from the implementation of practices, and hopefully this will lead to a higher implementation of the practices themselves. Finally, policymakers may benefit from this study by having more knowledge to incentivize the implementation of sustainable and resilient supply chains.

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