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Supply Chain Management in times of COVID-19. An exploratory study in Switzerland

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Abstract : The measures implemented in Switzerland and globally in response to COVID-19 have had a substantial impact on supply chains, which have been expanding internationally since the 1980s. This exploratory study is grounded in surveys and semi-structured interviews with Swiss companies. It identifies critical vulnerabilities primarily in forecasting volatile customer demand and in managing frequent supplier delays. In response to these challenges, companies have adopted several strategies, including increasing safety stocks, leveraging software (ERP, WMS, and CRM), and fostering collaboration among stakeholders through mutualization efforts. Despite limitations in sample size and geographical scope, limited exclusively to Switzerland, the study offers actionable insights for Supply Chain managers aiming to strengthen resilience against future disruptions.

Keywords : supply chain resilience; COVID-19; Switzerland; mutualization

Gestion des chaînes d'approvisionnement face au COVID-19 : une étude exploratoire en Suisse

Résumé : Les mesures mises en œuvre en Suisse et à l'échelle mondiale en réponse au COVID-19 ont fortement affecté les chaînes d'approvisionnement, qui se sont développées à l'échelle internationale depuis les années 1980. Cette étude exploratoire repose sur des enquêtes et des entretiens semi-directifs menés auprès d'entreprises suisses. Elle met en évidence des vulnérabilités majeures, notamment dans la prévision d'une demande client volatile et la gestion des retards fréquents des fournisseurs. Pour relever ces défis, les entreprises ont adopté plusieurs stratégies, notamment l'augmentation des stocks de sécurité, l'utilisation de logiciels (ERP, WMS et CRM) et la collaboration entre les parties prenantes grâce à des efforts de mutualisation. Malgré les limites liées à la taille de l'échantillon et à une portée géographique restreinte à la Suisse, l'étude fournit des enseignements concrets à l'intention des responsables Supply Chain souhaitant renforcer la résilience face à de futures perturbations.

Mots clés : résilience de la Supply Chain ; COVID-19 ; Suisse ; mutualisation

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*This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article.

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1. INTRODUCTION

Driven by cost optimization and customer requirements (Ponomarov & Holcomb, 2009), global supply chains (SCs) have increasingly become more complex (Bode & Wagner, 2015; Hussain et al., 2023) and involve a growing number of stakeholders (Boulay & Grandclement, 2019). This geographical dispersion has led to increased fragility (Tite et al., 2014). Although past scandals such as Nike and H&M have highlighted some vulnerabilities (Andersen & Skjoett-Larsen, 2009), the COVID-19 crisis revealed deeper systemic flaws. This widespread disruption created uncertainty in the development of resilience in companies' SCs (Ivanov, 2020, 2024b; Ozdemir et al., 2022; Spieske & Birkel, 2021). "Unlike other previous outbreaks, this pandemic has impacted all the nodes (SC members) and edges (ties) in a SC simultaneously" (Chowdhury et al., 2021, p. 2). The pandemic was unprecedented in both duration and geographical reach, affecting over 210 countries and nearly all sectors on both the demand and supply sides (Xu et al., 2020). In this context, it is important to examine how this unprecedented crisis has affected Swiss companies. This paper investigates the magnitude of the pandemic's impact and the measures taken by the Swiss Federal Council, analyzing how firms reorganized in response to the most significant supply chain crisis since the mid-20th century.

This study is guided by two main research questions:

RQ1. Where lie the vulnerabilities within Swiss companies' supply chains?

RQ2. Have Swiss companies applied measures recommended in academic and grey literature to cope with COVID-19 disruption?

To answer those questions, we conducted two online surveys based on a literature review and our expertise. We also conducted semi-structured interviews with SC practitioners. While this is not a systematic literature review, it provides valuable insights for decision-makers and contributes to the literature by examining resilience-building strategies in a highly industrialized yet regionally distinct SC landscape.

The following section outlines the components of SC vulnerability and the effective measures to respond to disruptions. After presenting the methodology used to collect the data, the study reports on key findings regarding vulnerabilities, measures, and best practices adopted by Swiss firms. The paper concludes with a discussion of the results and their implications.

2. LITERATURE REVIEW

This section presents a comprehensive literature review of vulnerability drivers in SCs and the measures to build resilient SCs.

2.1 Drivers of supply chain vulnerability

SC vulnerability refers to the extent to which a SC is exposed to disruptions that may hinder its ability to operate efficiently and serve end customers (Sharma et al., 2023). These disruptions may originate from internal organizational weaknesses or external environmental factors (Agrawal & Jain, 2022; Hussain et al., 2023). Peck (2006) distinguishes between internal and external risks within the SC network, while Wagner & Bode (2006) identify three main sources of risk: demand volatility, supplier-related issues, and large-scale disruptive events such as pandemics. Additional risk factors include globalization, ripple effects, and excessive dependence on single sources or geographic locations (Ivanov & Das, 2020; Shishodia et al., 2023; van Hoek, 2020). According to Christopher & Peck (2004), these vulnerability drivers can be classified as internal to the firm, external but within the supply chain network, or external to the network itself. Manuj & Mentzer (2008) further classify vulnerabilities into operational (e.g., manufacturing capabilities), informational (e.g., system security), and regulatory (e.g., policy changes) dimensions. Sharma et al., (2023) synthesized 26 critical vulnerability factors and grouped them into four categories: supply chain structure, organizational complexity, inter-organizational relationships, and information management. The pandemic has particularly

amplified these vulnerabilities for micro, small, and medium-sized enterprises which often face constraints in resources, structural limitations, and exposure to geographic and sectoral risks (Canwat, 2024). Moreover, poor human resource management practices, such as inadequate retention strategies, exacerbate workforce instability and further weaken SC resilience (Kok & Akbari, 2023; Narasimhan & Talluri, 2009; Singh et al., 2025). This framework provides a comprehensive lens through which the specific vulnerabilities identified in this study can be interpreted.

2.2 Measures to build a resilient supply chain

The concepts of vulnerability and resilience are closely linked as resilience is regarded as an element within a SC's capacity to respond, thereby influencing the assessment of the vulnerability of SCs (Elleuch et al., 2016; Ivanov, 2024b; Ozdemir et al., 2022; Shen & Sun, 2023). Resilience refers to the capacity of a SC to withstand disruptions, reorganize effectively, and maintain its core functions in the face of internal or external shocks (Bhatia et al., 2013; Tukamuhabwa et al., 2015; Wieland & Wallenburg, 2013). According to Ivanov, (2024), resilience is characteristic of the SC, emphasizing adaptability and persistence over time. Nikookar et al., (2024) further elaborate on this concept by introducing the concept of antifragility, defined as the capacity of a SC to not only withstand disruptions but also to derive benefits, both financial and non-financial, from such challenges Given the complexity and interdependence of modern SCs, transparency and information traceability are essential for identifying and mitigating vulnerabilities (Bode & Wagner, 2015; Jain et al., 2017). SC visibility functions as a mediating construct between information sharing, data connectivity, and reduction in behavioral uncertainty, thereby enhancing trust and commitment among SC partners to improve cooperation, ultimately leading to the achievement of resilient SCs (Dubey et al., 2019; Ye et al., 2022). However, visibility to only Tier 1 suppliers may be inadequate for most organizations seeking to manage supply disruption risks (Butt, 2022). However, the ability to trace SCs beyond Tier 1 suppliers remains limited among organizations, with the implementation of advanced digital solutions being a common requirement to ensure reliable traceability across multiple tiers of suppliers (Kilpatrick & Barter, 2020). Given that SCs generally traverse multiple corporate entities, effective risk identification and management necessitate a substantial degree of collaboration (Duong & Chong, 2020; Zhou et al., 2024). Consequently, cooperation between suppliers and customers is imperative for enhancing SC resilience (Christopher & Peck, 2004; Gunasekaran et al., 2017; Hägele et al., 2023; Hosseini et al., 2019; Ivanov et al., 2014; Ponomarov & Holcomb, 2009; Shishodia et al., 2023). In addition to relational strategies, physical and operational slack, such as capacity buffers and inventory reserves, plays a key role in managing demand surges and supply disruptions (Christopher & Peck, 2004; Ivanov, 2024a; Pettit et al., 2010; Purvis et al., 2016; Shahed et al., 2021). Moreover, the integration of information systems has been identified as a pivotal factor in fostering coordination among the entities forming the SC. These systems facilitate the exchange, dissemination, and availability of information throughout the global SC, thereby enhancing operational efficiency and responsiveness (El Baz & Ruel, 2024; Elkharraz & Moukadem, 2019; Evrard Samuel & Ruel, 2013; Mensah et al., 2015; Tatoglu et al., 2016). The integration of emerging technologies, including blockchain and next-generation ERP solutions, further strengthens these capabilities (Emrouznejad et al., 2023; Gunasekaran et al., 2017; Hägele et al., 2023; Min, 2019). Other essential resilience-building measures include business continuity planning (Pettit et al., 2010) and human resources contingency plans (Brandon-Jones et al., 2014) which ensure workforce stability. Additionally, dynamic planning tools and stress-testing procedures are increasingly recognized as complementary mechanisms that help firms both respond to immediate shocks and adapt structurally over time (Ivanov et al., 2023).

3. METHODOLOGY

This exploratory study combines online surveys and semi-structured interviews to analyze the

vulnerabilities and resilience strategies of Swiss companies during the COVID-19 crisis. This mixed-methods approach was selected to encompass both the breadth (quantitative survey) and depth (qualitative interviews) of the challenges faced by companies during the pandemic (Cole, 1965).

The first phase entailed the distribution of online questionnaires via email to a list of contacts (approximately 800 companies) compiled by the research team, as well as via LinkedIn. This survey was conducted in two rounds: in summer 2020 and spring 2021. A second phase of semi-structured interviews was then conducted to complement the study. Given that small and medium-sized Swiss enterprises (SMEs) constitute over 99% of the Swiss economy (Swiss Confederation, 2024), the initial round in summer 2020 targeted SMEs with fewer than 250 employees (Fueglistaller et al., 2011). The first survey was conducted in summer 2020, as European countries began easing lockdowns and reopening borders. The survey garnered 111 responses, of which 35 were deemed suitable for analysis following the exclusion of responses that were incomplete or did not meet the SMEs criteria.

In the first half of 2021, a second online questionnaire was sent to Swiss companies (approximately 1300 contacts) of all sizes to compare SME practices with those implemented by bigger companies, as well as looking at the development of those practices since summer 2020. The online survey was launched in March 2021, and the answers were collected until May 2021. The survey was slightly modified to refine certain topics and to make it more concise. The research team collected 105 responses and 64 were retained for analysis, because some questionnaires were not fully completed. The sizes of the companies were divided into four categories, micro companies (less than 10 employees), small companies (between 10 and 49), medium-sized companies (between 50 and 249) and large companies (over 250). The division is based on the Federal Office of Statistics (FOS). This second sample included a diverse range of companies in terms of size, with 40% representing large companies (over 250 employees) and 23% having over 1,000 employees. The participants are predominantly industrial companies from Western Switzerland (Figure 1). This is consistent with the regional anchoring of the research team and the available email address database. Regarding their activities, 70% of the respondents are manufacturing companies, involved in the production of watches, medical devices, or machinery.

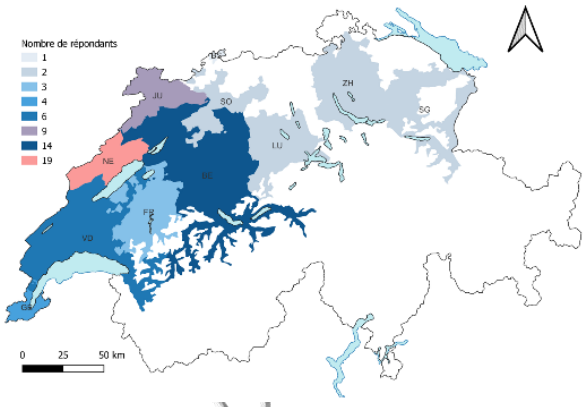

Figure 1. Geographical distribution of the sample.

The survey was designed to systematically capture SC vulnerabilities and the resilience measures implemented during the pandemic. Its development was guided by a literature review on these topics and enriched by the research team's professional expertise, ensuring both contextual relevance to Switzerland and practical applicability for supply chain practitioners.

The questionnaires were structured into four main sections:

- Supply Chain Vulnerabilities. Questions addressed key challenges such as demand forecasting, supplier dependencies, and delays.
- Measures Implemented. Respondents identified measures adopted to improve resilience.
- Resilience Assessment. Participants evaluated the overall resilience of their SCs before and after the pandemic using quantitative scales.
- Best Practices and Lessons Learned. Open-ended questions encouraged respondents to share innovative solutions and insights.

The second phase of the study involved the conduct of five semi-structured interviews with a selection of companies from the survey respondents. These companies were selected to reflect a range of resilience levels, from those showing lower resilience to those demonstrating higher levels, while ensuring diversity in industry representation. A structured interview guide was developed to explore three main themes, reflecting those in the surveys:

1. The impact of the crisis on the company's SC.
2. Measures implemented to mitigate disruptions.
3. Key lessons learned from the crisis.

All interviews were recorded, transcribed and analyzed using thematic analysis to identify common patterns and insights in building SC resilience (Braun & Clarke, 2006). This approach yielded qualitative insights into the practical challenges faced by companies and the strategies they adopted during the pandemic. Participants included SC managers and executives, ensuring access to decision-making perspectives. Some participants agreed to be quoted while others preferred to remain anonymous.

4. RESULTS

4.1 Supply chain vulnerabilities

The initial inquiry in the online survey asked that respondents evaluate the repercussions of the pandemic on their operations employing a 5-point Likert scale, as depicted in Figure 2. The results indicate that the overall impact of the COVID-19 crisis on companies has increased slightly compared to the first survey conducted in the summer of 2020.

This observation is corroborated by a marginal increase in the mean value, suggesting that while certain companies have adapted, the protracted nature of the pandemic persists in exerting strain on their operations, particularly among larger firms with more intricate SCs. The initial survey had already revealed a modest correlation between the size of the company and the impact of the crisis. To further explore this association, a Kruskal-Wallis H test was conducted, which revealed a statistically significant relationship between company size and the impact of the crisis. The analysis yielded a statistically significant result ($H(2) = 11.86$, $p = 0.003$), indicating that larger companies experienced a more pronounced negative impact in comparison to smaller and medium-sized enterprises. The mean ranks were 42 for large companies, 26 for medium-sized companies, and 26 for small and micro companies (Tables 1 and 2). It is noteworthy that only one company reported being unaffected by the pandemic.

Table 1. Descriptive Statistics for impact of the crisis by company size.

Descriptive Statistics for impact of the crisis by company size

Groupe	n	Mean	SD	Mean rank
Micro and small companies	22	3.32	0.995	26
Medium-sized companies	16	3.25	1.065	26
Large companies	26	4.19	0.849	42

Table 2. Statistical test.

Statistical test[a,b]

	To what extend do you estimate that your activities have been affected by the COVID-19 crisis?
Kruskal-Wallis H	11.86
ddl	2
Sig. asymptotic	0.003

a. Kruskal Wallis test

b. Grouping Variable : *Companies'size*

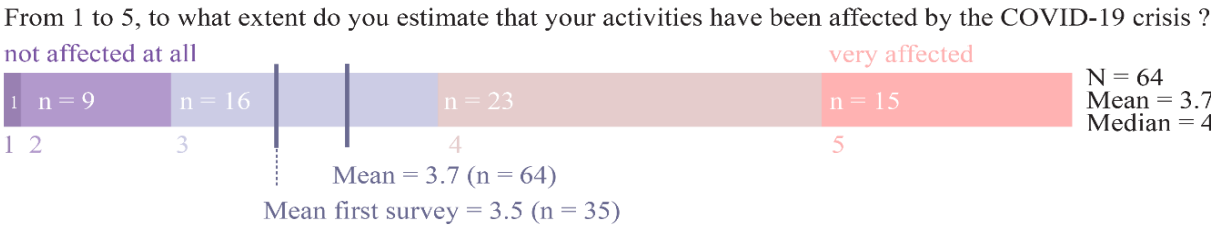

Figure 2.Impact of the crisis. Comparing mean values of the first and second survey.

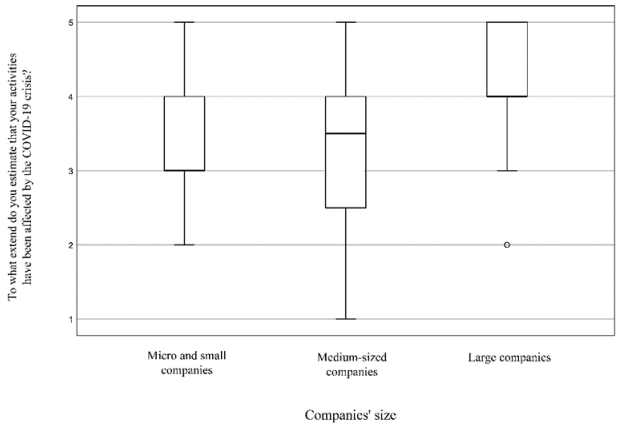

Figure 3.Box plot with whiskers and outliers.

As illustrated in Figure 3, large companies experienced a greater impact from the crisis compared to micro and small companies, as well as medium-sized companies with respect to "inflexibility in production capacity" and "frequent delays in delivery to customers." Conversely, medium-sized companies showed a higher degree of vulnerability in the context of "financial capacity". This phenomenon can be partially attributed to the increased complexity of their upstream and downstream flows, as well as the number of stakeholders involved in their SC. The Head of Demand and Supply Planning at Nestlé Suisse further elaborates on this point, stating, "*Large companies' dependency on multiple actors is greater. In contrast, an SME possesses a more concentrated value chain, with a more meticulous management of each element*". The ability of some small companies to reconfigure their activities is facilitated by their size, as they are in closer proximity to their customers, a finding that aligns with the observations reported by Canwat, (2024).

The next questions centered on the specific repercussions of the crisis on the companies' SC operations. Participants were asked to estimate the degree of vulnerability of their SC based on 15 items. As illustrated in Figure 4, the results are presented and the responses are arranged according to the average score assigned to each category, from the most vulnerable to the least vulnerable. The number of responses is indicated to the right of each item. In both surveys, the "no or poor forecasting" option distinctly deviates from the other responses. This finding underscores the persistent challenge faced by companies of all sizes in effectively executing forecasting exercises. Another notable finding is the direct focus on "relationships with customers and suppliers" in three of the initial five responses, which aligns closely with the findings reported by Sharma et al., (2023). The semi-structured interviews further corroborate the inherent difficulties in establishing forecasts, particularly with respect to demand. The prevailing tendency among companies to rely on historical data for future planning has been further compounded by the uncertainty exacerbated by the pandemic, underscoring the inherent challenges in predicting future outcomes. The volatility in demand can be attributed to the shifting behaviors of end customers, influenced by the dynamic measures implemented by the Federal Council, such as travel restrictions, partial confinement and teleworking. Consequently, the reliability of statistical models based on historical data became compromised.

The study also shows that "dependency on suppliers" and "frequent supplier delays" are among the elements considered most vulnerable. The global pandemic has underscored the profound interdependence of companies on their suppliers, particularly those based in Asia. This phenomenon is further compounded by the tendency of companies to use the same strategic suppliers for various products. For instance, a pharmaceutical company noted that it had the same suppliers as companies that manufacture vaccines for the novel virus, and therefore, the company was not their priority. This underscores the potential cascading repercussions of SC disruptions, which can hurt businesses across various firms.

Another vulnerability pertains to human resources management: "*we were compelled to modify our operational protocols and divide into two teams to prevent the transmission of the virus among personnel for an extended period. This alteration led to adjustments in the day-to-day organization and extended schedules. However, it was deemed imperative to ensure business continuity*". This transition resulted in a notable decline in employee motivation over the course of several months.

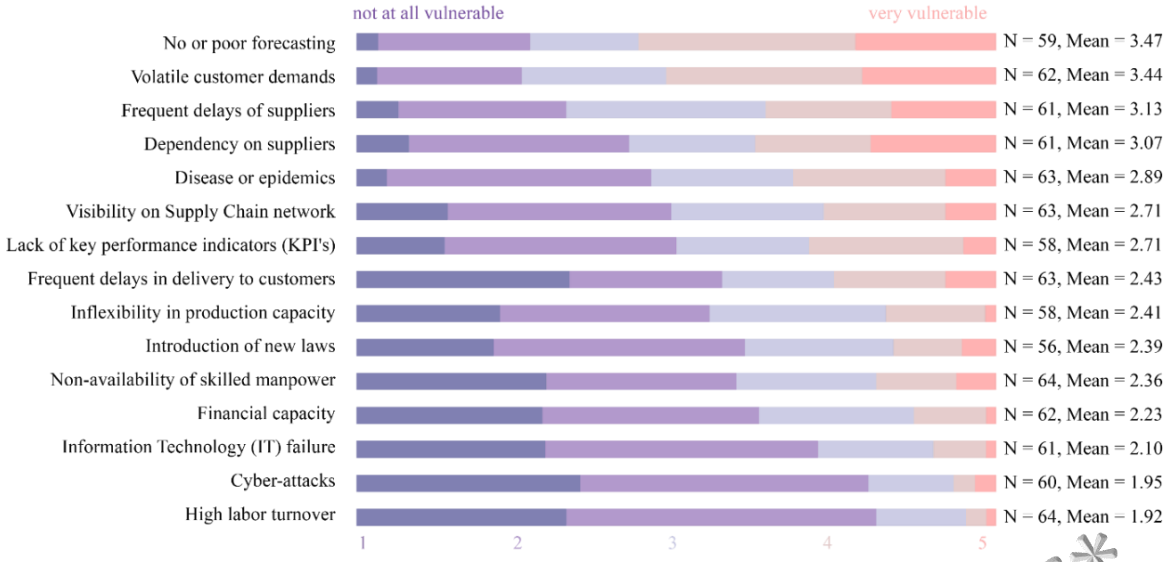

Figure 4.Vulnerabilities.

4.2 Measures in response to COVID-19

To better understand the way companies responded to the crisis, the questionnaire presented a list of measures to participants, with these measures derived from a review of the extant literature. Participants were instructed to indicate the measures implemented and subsequently to evaluate their effectiveness on a scale ranging from 1 (not at all effective) to 5 (very effective). The results are illustrated in Figure 5, which groups all the results and ranks the proposed items according to their effectiveness.

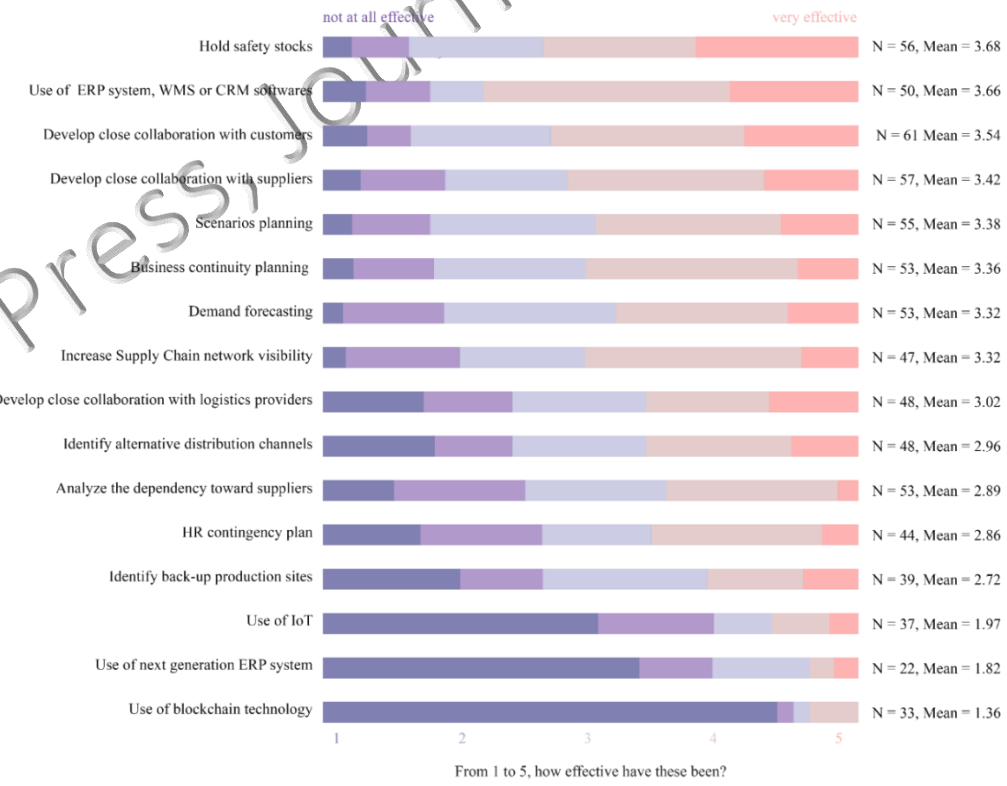

Figure 5. Measures taken.

The measure that clearly stands out is "Holding safety stocks". This term encompasses not only raw materials and components but also the inventory of personal protective equipment (PPE), including masks and gloves, ensuring the safety of employees in the workplace. This item's ranking has increased in comparison to the previous survey, in which it was placed fourth. The discrepancy in the rankings can be attributed to the temporal difference of nearly eight months between the two surveys. This suggests that as crises persist, there is an increasing adoption of safety stock as a crisis management strategy. Most managers surveyed reported having accumulated inventory in anticipation of the post-crisis environment. Some companies highlighted that their "zero stock" strategy inherited from the adoption of lean management philosophy made their SC fragile. "*For financial performance, many companies have work processes that are close to Just in Time (JIT) and have inventory levels that are generally quite low. This means that, in case of disruption, they will very quickly find themselves at the limits of these systems, which are parameterized for an expected mode of operation with a known and calculated volatility from which statistically viable safety stocks are deduced. This over-optimization may result in more fragile SCs*" (Head of Demand and Supply Planning at Nestlé Suisse).

A second effective measure indicated by the participants is the "use of ERP system, WMS or CRM software", which was a new element proposed in the online survey. It was added to understand if companies use at least commonly available software to support SC management compared to advanced technologies. Then, "collaboration with customers and suppliers" within the SC was still highly rated by the companies as an essential measure to overcome disruptions. This point was also confirmed in the semi-structured interviews: "*we spoke to three key suppliers that we could not easily replace to find out their perception of the situation and to find out whether they were able to deliver or not*" (Managing Director at Idonus Sarl). While most companies already had effective collaboration tools, such as Vendor Managed Inventory, in place before the crisis, it was still necessary to further strengthen the relationship: "*when the crisis began, we approached our main customers and asked them for which products they could not afford a shortage, then we prioritized these products to guarantee supply, either through in-house production or through partnerships with subcontractors or suppliers*" (CEO of Bergeon SA). In the online questionnaire, some respondents also highlighted the importance of multiple sourcing and the need to have suppliers located in different countries, or even continents, to avoid supply disruptions. The pandemic also pushed companies to the limits of their existing collaborations; in some cases, relationships were severely damaged: "*we realized that some of the suppliers we thought we had a good relationship with ended up not being so good because they let us down*" (Head of local Supply Chain at Takeda). However, SC collaboration remains an essential measure because it enables the three main dimensions of SC resilience to be addressed: preparedness, response, and recovery. "A strategy is considered effective for preparedness if it is preemptive for future disruption readiness; for the response, if it can help members of the SC respond quickly to minimize the immediate impacts; and for recovery, if it can help the SC return to its original or even a better state" (Chowdhury et al., 2021, p. 12).

At the bottom of Figure 5, it is interesting to note that the least mentioned elements concern all new technologies, regardless of the size of the companies. This is despite recent literature suggesting that one approach to building resilience in SCs is to accelerate technology adoption (van Hoek, 2020). Authors report that lockdown measures have forced many companies to fundamentally change the way they buy and sell goods and services and become more digital (Baig et al., 2020). The digitalization of SCs should play an important role in enterprise resilience by enabling shorter response times and faster adaptation to change, and by improving the control of ripple effects in the event of an epidemic outbreak (Ivanov, 2020). In particular, the Internet of Things (IoT), cyber-physical systems, blockchain and smart contracts enable the realization of peer-to-peer

networks that can mitigate risks in times of uncertainty (Makridakis & Christodoulou, 2019; Wasim Layaq et al., 2019). Very few of the companies in the sample reported using those technologies which can be explained by various elements. During the semi-structured interviews, executives explained that despite their desire to increase SC visibility, they lack the time to develop these technological tools. Others said they saw some benefits to the approach but were concerned about adding unnecessary complexity to their SC. One company even pointed out the limitations of advanced technologies: "*you can put all the intelligence behind it but if a supplier fails you, it fails you*" (Head of local Supply Chain at Takeda). Among the other measures that are most derived from the situation, 55 respondents reported using "scenario planning", 53 had resources for "business continuity planning", 53 mentioned "demand forecasting", and finally 47 sought to "increase visibility of their SC activities".

4.3 Supply chain resilience

Has the crisis made companies' SCs more resilient? Figure 6 indicates a slight upward trend in SC resilience, with the average score increasing from 3.11 in summer 2020 to 3.59 in the first half of 2021. However, this improvement remains moderate.

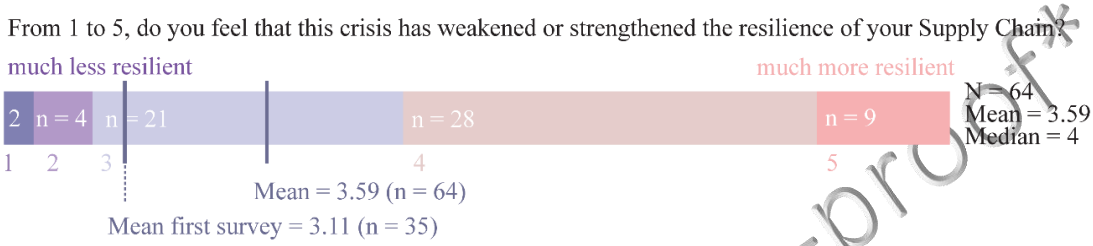

Figure 6. Supply Chain Resilience.

Most respondents chose the median of this scale (20 respondents ticked 3), followed by a score of 4 (9 respondents), with the remaining five responses split between the other scores. It appears that the crisis has not significantly increased SC resilience. However, it is interesting to note that this question is the only one that significantly divided the companies in the sample according to their size. In fact, a statistical test (Kruskal-Wallis) shows that the result for this question was lower for micro and small companies than for medium-sized companies. While the size of the sample suggests that this result should be treated with caution, it might be interesting to try to understand the difference between these components. Was it the lack of human, and probably financial, resources that prevented the smaller firms from improving their SC resilience, or was it their organizational capacity to cope with disruptions due to their size? As noted in the literature, SC resilience can be understood as "the capacity of a supply chain to persist, adapt, or transform in the face of change" (Wieland & Durach, 2021, p. 2) which may support the second hypothesis. Smaller organizations may be more agile in adapting to crises.

4.4 Supply chain practices

Finally, the last question "How have your company's SC practices changed as a result of this health crisis?" allowed the participants to answer in an open-ended manner. The most common changes in practices were primarily related to communication. Participants in the online questionnaire mentioned that they had "*more regular communication with suppliers, especially regarding lead time tracking*". A second practice reported by participants is collaboration among stakeholders. One company stated that "*collaboration between the SC, quality and legal departments has been strengthened*". This was also confirmed in the semi-structured interviews: "*we set up very quickly with the sales teams to get feedback from the field to understand what is going on, to know what to produce and when to stop*" (Head of Demand and Supply Planning at Nestlé Suisse).

In the context of the pandemic, some companies were able to set up crisis management committees,

which had previously been discussed. These committees were tasked, for example, with analyzing the directives issued by the Swiss Federal Council and then formulating specific recommendations for management to enable rapid decision-making. This approach was praised as an effective measure, with members expressing confidence in their ability to make informed decisions and anticipate potential challenges. This approach is seen as a powerful tool for cultivating SC resilience within an organization (Al Naimi et al., 2022).

To ensure business continuity, companies documented the various alternatives they explored (alternate production sites or distribution channels). Other participants in the interviews regarded the internalization of production as commendable practice in case of a crisis: "*in the past, we placed significant reliance on our subcontracting network. However, in the current environment, we have taken every possible measure to internalize our operations*" (CEO of Bergeon SA). This enterprise has successfully adapted its business model during challenging periods, as shown by its ability to transition from a subcontracting-based model to an in-house production approach. "*Given our longstanding practice of importing cleaning products for work surfaces, we have cultivated privileged relationships with companies that have received certification from the Chinese government. Consequently, we have had access to formalized products that can be exported from China. In a matter of weeks, we obtained half a million certified masks, which became a temporary business activity*" (CEO of Bergeon SA). This approach aligns with the concept of "qualitative manufacturing repurposing," which involves the temporary production of items not directly related to a company's primary business activities (Ardolino et al., 2022). Conversely, others have perceived the crisis as a catalyst for accelerating business diversification initiatives initiated in previous years, enhancing the company's online presence, and conducting social media marketing campaigns, leveraging the fact that the population was largely confined to their homes (Nikookar et al., 2024).

Furthermore, the results of the online questionnaire indicated that the crisis has proved the advantage of sourcing within national borders. The strategic shortening of SCs and the establishment of proximity to suppliers has emerged as a timely strategy, echoing the phenomenon of "slowbalization" (Kandil et al., 2020), characterized by a deceleration of economic international exchanges. Furthermore, companies that prioritize local sourcing appear to have proven a higher degree of resilience in the face of the crisis. "This crisis underscores the notion that localized systems exhibit greater resilience in comparison to global SCs" (Sarkis, 2021, p. 4).

One company has indicated its intention to reduce the number of intermediaries to enhance visibility and exert greater control over its upstream and downstream SC. This observation suggests that a significant proportion of companies have identified challenges in their supply networks and have opted to revise their procurement strategies, characterized by increased proximity and frequency, and occasionally, transitioning from single sourcing to double or even triple sourcing.

Another salient issue that emerged during our study pertains to the concept of mutualization. For instance, when shortages of PPE arose in Switzerland, the Head of Local Supply Chain at Takeda mobilized its network to mutualize gloves and masks, ensuring the safety of workers and maintaining production continuity. However, this approach is not without its challenges, as some observers express reservations about its effectiveness and the feasibility of implementing it across the entire medical sector. "*While it may enhance bargaining power with certain suppliers, implementing this strategy in the medical sector poses significant challenges*" (Executive Vice President of Operations at Spineart).

Finally, in the online survey, participants noted that "*teleworking has demonstrated our capacity to orchestrate the SC in a decentralized manner. Teams have become more autonomous and polyvalent*." However, it should be noted that remote work is not yet possible for all SC professions, such as production or warehouse operators. The feasibility

of remote work varies significantly depending on the degree of company autonomy.

5. DISCUSSION

The findings are consistent with the extant literature on SC resilience, which underscores the significance of enhancing visibility, collaboration, inventory management, and information technology in mitigating disruptions (Ivanov & Dolgui, 2020; van Hoek, 2020). The study also underscores that localized SCs exhibit greater resilience compared to their global counterparts (Sarkis, 2021). This strategic shift towards domestic sourcing within national borders has proven helpful during the pandemic. However, the findings reveal a discrepancy between this observation and the literature on digitalization as a pivotal resilience strategy (Baig et al., 2020; Benzidia & Bentahar, 2023; Ivanov & Dolgui, 2021). This discrepancy presents a significant opportunity for the advancement and investment in Swiss SCs.

Considering these insights, the next section addresses the two research questions that guided this study.

Regarding RQ1, a close examination reveals that Swiss companies' SCs are particularly vulnerable to two key issues: managing demand uncertainty and ensuring supplier reliability. Many companies, especially larger ones, faced challenges due to their dependency on multiple actors and complex upstream and downstream flows. The pandemic's repercussions on consumer behavior, in conjunction with the Swiss Federal Council's evolving measures (e.g., travel restrictions, partial confinement, teleworking, and restaurant closures), compounded these forecasting challenges. The dependency on suppliers, particularly those based in Asia, has also led to significant disruptions. For instance, some companies found themselves in direct competition with manufacturers of the vaccines for the prevention of the novel strain of the virus, which led to delays and cascading impacts throughout their supply networks. Modifications to work patterns, such as the implementation of team-based work to mitigate the spread of infection and extended work schedules, have also had a significant impact on employee motivation and overall operational efficiency.

To answer RQ2, our exploratory study shows that Swiss companies have implemented several significant measures to cope with the pandemic, in line with recommendations from both academic and grey literature. These measures include:

1. Holding safety stocks. This strategy has been the most widely implemented and has proven to be the most effective. Companies augmented their inventories with raw materials and PPE, ensuring business continuity.
2. The use of ERP, WMS, and CRM software was also observed. These systems were widely used to support SC management, highlighting a reliance on established digital tools rather than advanced technologies like IoT or blockchain.
3. A notable feature of this period was the reinforcement of stakeholder relationships, with improved communication and close coordination with suppliers and customers playing a critical role. The regular convening of meetings and the dissemination of data were instrumental in enabling companies to swiftly adapt to evolving circumstances.
4. Scenario and business continuity planning. These measures were also common, with companies mapping out single-source dependencies and identifying backup production sites.

5.1 Limitations

While these findings are insightful, their interpretation must consider certain methodological limitations. The sample size, while adequate for an exploratory study, may restrict the generalizability of the findings. Furthermore, the focus on companies located in Western Switzerland could introduce a regional bias, given the heterogeneity in economic and cultural conditions across the country. The reliance on self-reported data from surveys and interviews introduces potential biases. Conducting in-depth, multi-tier case studies across various sectors following the surveys would have been ideal for validating the findings. However, this approach was not feasible due to limitations in terms of time and resources. To

mitigate these biases, efforts included diversifying the population in semi-structured interviews and conducting multiple rounds of data collection.

5.2 Practical implications for supply chain managers

Despite these limitations, the study yields several practical implications for SC managers seeking to enhance resilience. The challenges associated with forecasting volatile demand underscore the necessity of investing in advanced predictive tools powered by artificial intelligence (AI) and machine learning (Aamer et al., 2021; Carbonneau et al., 2008; Dalimunthe et al., 2023; Douaioui et al., 2024; Khan et al., 2020). Furthermore, the incorporation of scenario planning into strategic decision-making processes can facilitate proactive anticipation of fluctuations and enable businesses to adapt accordingly (Joglekar & Phadnis, 2021; Kohl et al., 2022; Olivares-Aguila & Vital-Soto, 2021). SC disruptions can be mitigated by strengthening supplier relationships and diversifying sourcing strategies. A multi-sourcing approach, in which a company relies on multiple suppliers, can reduce dependency on a single supplier and enhance SC flexibility. Although JIT inventory management maintains its efficacy under typical circumstances, the adoption of a hybrid strategy that integrates lean operations with strategic buffer stocks for critical components can markedly enhance resilience during periods of uncertainty (Brakman et al., 2020; Jiang et al., 2022). Furthermore, the crisis has underscored the importance of effective coordination among logistics, procurement, and operations teams. The establishment of clear communication channels and the investment in workforce training to enhance adaptability and responsiveness are essential for ensuring operational continuity and long-term SC resilience. Furthermore, numerous companies have highlighted teleworking as a key strategy. For instance, one participant in the online questionnaire noted that "*while we have implemented a novel, more flexible organizational structure to address physical logistics, the crisis has highlighted the feasibility of remote administration, a possibility that was not immediately apparent*". While the significance of teleworking was repeatedly underscored, several participants also highlighted the potential management challenges it could pose, both within organizations and in their interactions with suppliers, who, at times, were challenging to reach due to their own restructuring processes.

5.3 Sustainable implications of supply chain resilience

Beyond operational considerations, the findings also raise important questions regarding the integration of sustainability into resilience strategies. Future efforts to strengthen SC resilience should incorporate environmental and social dimensions. This includes embedding circular economy principles, reducing carbon emissions, and fostering responsible sourcing practices (Sarkis, 2021). In parallel, gender diversity must be recognized as a strategic lever for building sustainable and resilient supply chains. For example, increasing the representation of women in SC and industrial sectors is essential for Switzerland's long-term competitiveness and sustainability (Doan & Briquez, 2024). Diverse teams are associated with greater creativity, broader systems thinking, and more participatory forms of governance, which enrich both processes and decision-making. From a managerial standpoint, gender diversity often brings complementary soft skills such as empathy and active listening. Operationally, it also supports the integration of social dimensions, such as respect for rules, attention to risks, and stronger interpersonal relations, into core SC processes (Ruel & Fritz, 2021). Companies that adopt this approach tend to have better financial performance (Chin & Tat, 2015; de Luis-Carnicer et al., 2008). Therefore, encouraging the participation of women in traditionally men-dominated SC professions is not only a matter of equity, but also of strategic value. This can be achieved through targeted initiatives including awareness-raising, capacity-building, and career support programs. Promoting women retention and leadership in SC roles is critical to sustaining this dynamic. According to the 2025 Global Gender Gap Index, no nation has yet achieved full gender equality, for example Switzerland holds the 17th place out of 148 countries (World Economic Forum WEF, 2025). This multifaceted approach, encompassing awareness-raising, training, and support, is instrumental in unleashing the potential of women as pivotal contributors to the development of sustainable and

resilient SCs (Barrientos, 2023; Ma et al., 2021; Ruel et al., 2020; Ruel & Fritz, 2021; Zinn et al., 2018).

5.4 Swiss context

These results must also be interpreted considering Switzerland's specific economic and institutional context. The Swiss economy is distinguished by a high level of innovation, a robust industrial base, and a predominance of SMEs, which account for over 99% of all companies (Office fédéral de la statistique, 2023). Swiss companies depend on high-precision manufacturing and are deeply reliant on global SCs, making them particularly vulnerable to international disruptions. The Swiss Federal Council's measures during the pandemic, including lockdowns and economic support packages, influenced how companies navigated the crisis and implemented resilience strategies. While Swiss companies operate within a unique regulatory and economic environment, many of the challenges they faced, such as demand volatility, supplier delays, and disruptions in global trade, are common across industries and regions. Consequently, the findings may be particularly relevant to firms with similar SC structures, such as Germany and Austria (PWC, 2022), where reliance on international suppliers and JIT management practices are prevalent. Furthermore, insights derived from this study may hold relevance for companies operating within highly regulated sectors, such as pharmaceuticals, high-precision manufacturing, and luxury goods, given their shared reliance on global suppliers and stringent quality standards. However, it is important to exercise caution when extrapolating the results to emerging markets or industries with less integrated global supply networks.

5.5 Future research

Based on the insights generated, several promising avenues for future research can be identified. A particularly interesting domain for future investigation pertains to the mutualization of materials. During the pandemic, several companies adopted strategies to share resources, such as PPE, with other organizations, ensuring the continuity of operations. The concept of mutualization entails the consolidation of resources and competencies among disparate entities, thereby enhancing collective resilience (Camman et al., 2013; Goldbeck et al., 2020; Moutaoukil et al., 2012). Investigations into this approach could yield insights into how mutualization can mitigate vulnerabilities in SCs by easing access to critical materials during crises.

In parallel, future studies could examine how digital technologies (AI, blockchain, and IoT) enhance SC adaptability during disruptions (Abbad et al., 2025; Couzineau-Zegwaard & Meier, 2023; Pujawan & Bah, 2022). IoT enables real-time tracking of goods, infrastructure, and environmental conditions across the supply chain (Ben-Daya et al., 2019). It supports better visibility, predictive maintenance, and early disruption detection. When coupled with blockchain, these technologies can improve traceability, data integrity, and the reliability of exchanges across tiers (Chen et al., 2023). While these tools were largely absent from the practices of Swiss firms surveyed, their future integration could significantly enhance responsiveness, trust, and coordination in turbulent environments. A comparative analysis of companies that have adopted digital solutions versus those that rely on traditional approaches could provide actionable insights for practitioners.

Given the significant role of government interventions during the pandemic, further research could explore how policies such as financial aid, trade regulations, and SC risk management frameworks influence business resilience. Cross-country comparisons could facilitate the identification of optimal policymaking practices for future crises.

Taken together, these findings contribute to a better understanding of how Swiss companies have responded to the COVID-19 crisis, highlighting both structural vulnerabilities and concrete pathways toward more resilient supply chains.

6. CONCLUSION

This exploratory study provides valuable insights into the practices adopted by Swiss companies to manage their supply chains in the face of the

unprecedented disruptions caused by the COVID-19 pandemic. Despite the study's modest sample size, the combination of comprehensive quantitative surveys and qualitative interviews offers decision-makers actionable guidance for enhancing supply chain resilience. The analysis highlights key vulnerabilities, notably the challenge of forecasting volatile demand and securing reliable suppliers. These issues, especially prevalent among larger firms, align with Nikolopoulos et al. (2021), who emphasize the critical role of accurate forecasting in crisis decision-making.

In response to these vulnerabilities, Swiss companies have proactively strengthened their SCs by increasing inventory buffers, enhancing collaboration among stakeholders, and adopting enterprise software solutions (ERP, WMS, and CRM). The increase in safety stocks to absorb demand fluctuations proved essential (Pettit et al., 2010; van Hoek, 2020). Additionally, robust communication and data-sharing practices with suppliers and customers emerged as central elements in risk mitigation, in line with previous research (Christopher & Peck, 2004; Ivanov, 2020; Ivanov & Dolgui, 2020; van Hoek, 2020). Many companies also adopted localized sourcing strategies, leveraging regional strengths to reduce dependence on fragile global supply networks. Resource mutualization, especially for critical materials such as PPE, has also appeared as a promising practice to enhance regional resilience.

Nevertheless, a notable gap remains regarding the implementation of advanced digital technologies such as IoT and blockchain, despite their recognized potential to significantly improve SC transparency and resilience (Baig et al., 2020; Ivanov & Dolgui, 2021). Their use remains limited among the companies surveyed, presenting an opportunity for further development.

Finally, the unpredictable nature of the COVID-19 crisis highlights a critical limitation of existing risk management frameworks, reinforcing the notion that "*decisions as extreme as those taken by the authorities could not be part of a risk analysis*". In this context, both policymakers and business leaders must use the lessons learned to proactively strengthen SCs. Shifting from reactive resilience to strategic agility by refining inventory management practices, strengthening stakeholder collaboration, embracing digital transformation and fostering gender diversity will enable Swiss SCs to confidently navigate future uncertainties.

7. REMERCIEMENTS

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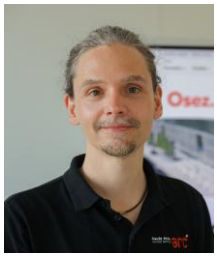

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