



The disruptive factors and longevity effects of Covid -19 and Brexit on the SMEs construction supply chain in the UK

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Abstract

Purpose

Supply chain disruptions have a significant impact on overall project delivery. This study aims to identify the supply chain disruptive factors and develop a framework to mitigate the disruptive effects on the supply chain. Covid-19 and Brexit disruption and their longevity effects in the short, medium, and long term on the supply chain are relied upon to develop the framework.

Method

The study adopted a mixed-method approach with a sequential explanatory design. The main disruptive factors were identified through a literature review, and key factors were selected through a focus group exercise. A questionnaire survey was carried out to sample opinions from the practitioners; 41 questionnaires were received and analysed using the relative importance index (RII) method for ranking the factors and percentage frequency distribution to determine the longevity effects. Five follow-up semi-structured interviews were conducted over the telephone and later transcribed.

Findings

The results of Covid 19 disruption indicate that material cost increase ranked first with (RII: 0.863), logistics cost increase, and supply chain interaction ranked second and third, respectively. They have long-term, medium-term, and short-term longevity effects, respectively. The lowest-rated factors were communication (RII: 0.561), staff shortages (RII: 0.629), and impact on relationships (RII: 0.639). The three most ranked Brexit disruptive factors are supply chain interaction (RII: 0.775), material cost increase (RII: 0.766), and logistic and haulage delay (RII: 0.717). The first two factors have long-term effects, and the logistics and haulage delays have a medium-term impact. The mitigating solutions suggested in the framework are collaborative working, stronger resilience to external forces, and better transparency and communication that will lead to good relationships among the supply chain members.

Research limitations/implications

The scope of the study was limited to the UK construction industry, however, the pandemic effect on supply chain can serve as critical learning curve in other developed and developing countries.

Practical implications

The study will help the government and construction firms to understand the focal areas of importance in solving the supply chain disruption problems based on the effects of Brexit and Covid19. The research would be useful in ensuring the proactive

involvement of the government and contracting firms in their preparedness for similar events in the future. The results could be interpreted for critical learning in other developed/developing countries.

Originality/value

Identifying and ranking the supply chain disruptive factors affecting the SMEs in the UK construction industry has been the focal point of this study. The study also proposes a simple but effective framework comprising the highly ranked factors, their longevity effects, and mitigating measures. This will help the SMEs manage future/similar external events affecting the supply chain.

Keywords: Disruptive factors, Covid-19, Brexit, Supply chain, longevity effects, UK

1. INTRODUCTION

1.1 Background to the study

Construction is one of the UK's largest growth sectors, which includes contracting, product manufacturing, and professional services. It contributed £138 billion to the UK's economy in 2016 (ONS 2021). Inefficiency in the sector has been linked with the construction supply chain (CSC), resulting in different reports, including the Latham Report (1994), The Egan Report (1998) and the Wolstenholme Review (2009) "Never Waste a Good Crisis". Segerstedt and Olofsson (2010) also show the need to improve work efficiency between subcontractors and suppliers within construction. Department for Business Innovation and Skills (2021) emphasises the need for greater client involvement and re-engineering supply chain management. Each report introduces supply chain management approaches through integrated working, relational contracting, and partnering arrangements (Oyegoke, 2007).

Over recent years the construction industry has encountered a series of problems, such as the economic uncertainty of Brexit and the devastating effects skilled labour shortages have within the construction industry (Salami et al., 2021a; Financial Times, 2021). ONS (2021b) indicates that there are problems with material shortages due to global supply chain issues, the EU exit, and the coronavirus (COVID-19) pandemic. Resulting in a 5% quarter-on-quarter stock level change in the construction industry due to increasing difficulty in getting products, due to project backlog and the additional strain due to DIY (do-it-yourself) projects by homeowners during the periods of lockdown (ONS 2021b).

According to Liu et al. (2022), COVID-19 has caused disruption and socio-economic devastation in the construction industry due to a strict lockdown that affected the entire Supply Chain Management (SCM). The upstream small-and medium-sized enterprises (SMEs) in the construction industry chain and has suffered high operating costs and tight cash flow problems due to Covid 19 (Liu et al., 2022). A critical pandemic impact (CPI) in key areas of the construction industry shows a reduction in construction productivity, foreign investment, demand for construction-related works, disruption in the supply chain, and the number of public projects (King et al., 2022). Cherian and Arun (2022) postulate that the effect of COVID-19 is more on medium-

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3 sized builders and developers and found a positive impact between Supply Chain (SC)
4 agility, resilience, and information technology (IT) capabilities on supply chain
5 performance. Osunsanmi et al. (2022) suggest a system to optimise CSC
6 management because of SC's weak resilience during Covid 19 through an evidence-
7 based management approach that is less dependent on implicit knowledge.
8

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10 Conversely, Brexit has significantly impacted supply chains and threatened to hold
11 back growth in the UK construction industry (Financial Times, 2021). The haulage
12 sector, essential, has suffered significant driver shortages, causing increased delays
13 and shortages (Marshall, 2021). The haulage sector crisis is creating significant effects
14 within the construction industry as material lead times are increasing and goods
15 haulage is becoming more expensive due to lack of labour and increased demand.
16 Moradlou et al. (2021) investigate the impact of Brexit on geopolitical disruptions on
17 the manufacturing supply chain (SC) location decision in UK multinational firms. Their
18 findings indicate that most companies will relocate production facilities from the UK
19 because of market-seeking and efficiency-seeking advantages. The construction
20 industry is dependent on low-skilled migrant labour, Walsh et al. (2022) suggest there
21 is a risk of labour exploitation due to the combined effects of Covid 19 and Brexit. They
22 concluded that there would be an increase in labour exploitation and neglect of due
23 diligence, especially further down the supply chain.
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26 Despite the UK construction industry suffering detrimentally during the COVID-19
27 pandemic, the construction sector was one of the first to get back up and running,
28 albeit with government restrictions in place (Procure Partnerships 2021). However,
29 supply chain issues have still prevailed due to stock being diminished through the
30 pandemic and the sector recovering faster than anticipated, suppressing supply and
31 demand (RICS 2021). Coupled with issues in supply chains caused by Brexit, a
32 shortfall of materials and goods, and other issues affecting the efficiency and
33 productivity levels of the UK's construction industry are still present (Building Merchant
34 Federation 2021).
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37 Abidina et al. (2018) suggest that supply chain disruptions have caused a wide-scale
38 impact on the construction industry, increasing project cost performance and time
39 overruns. The disorders arising from one party in a supply chain network affect other
40 parties in the chain. This is exacerbated in the UK by the combined effect of Brexit and
41 the global Covid 19 pandemic. This study aims to develop a framework through a
42 detailed analysis of the disruptive effects of Covid-19 and Brexit and their longevity
43 effects in the short, medium, and long term in the construction supply chain from a
44 contractor's perspective. The two objectives are:
45

- 46 • To identify and rank the supply chain disruption factors due to Covid-19 and
47 Brexit and their longevity effects in the short, medium, and long term.
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- 49 • To develop a framework through a detailed analysis of the effects of Covid-19
50 and Brexit on the construction supply chain disruption from contractors'
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2. LITERATURE REVIEW

2.1 Supply chain management

Projects are temporary and 'one-off' in nature (Akintoye et al., 2000; Oyegoke, 2007). This also leads to the difficulty in SCM application based on the multiple temporary organisation (Cheng et al., 2010) and the ability to form and maintain long-term relationships (Briscoe et al., 2004; Aloini et al., 2012). Construction SCM is an integrated set of practices to manage and coordinate the entire chain, from raw materials to end customers (Love, 2004). SCM focuses on managing cashflows within a programme and allows the suppliers, contractors, clients, and their agents to work together to install and utilise information to produce and deliver materials, plant, temporary works, equipment, labour, and other resources for construction projects (Behera, 2015). To avoid fragmentation and improve SCM performance, Vrijhoef and Koskela (2000) identified the relationship between the site and direct suppliers, which might lead to cost reductions in logistics and haulage. A focus on the site, early stages, integrated supply chain management, and site production are identified as critical factors.

Supply Chain Management (SCM) initially emerged from the manufacturing industry to increase overall business productivity, efficiency, and effectiveness (Akintoye, 2000). Christopher and Peck (2004) define the supply chain as "the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer". Despite the successful implementation of SCM within other industries, the construction industry has been recognised as slow and impractical in its adaptations of SCM initiatives (Gadde & Dubois, 2010). The ONS report (2021b) indicates that there are changing stock levels and shortages of material due to problems due to the supply chain in the UK.

Recently, Jraisat et al. (2021) examined if a triad collaboration mechanism is needed in a sustainable supply chain. They suggested contextual factors that impact the associations between collaboration mechanisms, information-sharing activities, and sustainability performance. Cigolini et al. (2022) examined construction and complex engineering projects as ETO supply chains, where products are designed, engineered, and finished after an order has been received. ETO projects are characterised by greater complexity and often require customisation, supply-demand imbalance, and performance. A cross-functional integration was suggested to respond to the complexities (Cigolini et al., 2022).

2.2 Supply chain disruption factors

Throughout history, there have been several supply chain disruptions as a result of both natural and manmade disasters. The manmade disasters creating such disruptions are growing exponentially (Blackhurst et al., 2005). Shojaei & Haeri (2019) acknowledged that supply chains are 'inherently risky, therefore playing a pivotal role in successfully delivering construction projects. Bode & Wagner (2015) define supply chain disruption as the "combination of an unintended and unexpected triggering event that occurs somewhere in the upstream supply chain, the inbound logistics network,

or the purchasing (sourcing) environment, and the consequent situation that presents a serious threat to the normal course of business operations of the focal firm”.

According to Kamalahmadi and Parast (2017), a firm's supply chain is exposed to supply, environmental, and interdependence risks. Supply risks disrupt an individual supplier, environmental risks disrupt suppliers in a given region, and supplier interdependence risks lead to the disruption of other active suppliers. Due to the frequency of external and internal disruptive events, many firms have incorporated risk into their purchasing and sourcing strategies to reduce vulnerability and ensure continuity (Chopra & Sodhi, 2014). The global supply chain network has also made firms vulnerable to supply chain disruptions (Bode & Wagner, 2015). Sawik (2020) uses multiple criteria decision-making methods to mitigate the impact of supply chain disruptions and suggests prevention, response, protection, and recovery strategies. It comprises risk-averse models to minimise expected worst-case scenarios by single sourcing. Golan et al. (2020) postulate that epidemics and pandemics are unique disruptions because they are systemic threats as the suppliers, transportation, and the command-and-control network are disrupted during an epidemic.

2.2.1 Covid-19 effects on supply chains disruption

The effects of COVID-19 have affected supply chains within the construction industry on a global scale. A recent RICS (2021) survey highlights that the pandemic has increased pressure on ‘the already stressed industry. The survey also indicates that 40% of professionals from the construction sector on a global scale experienced issues and disputes due to Covid-19 (RICS 2021). Combining this with Brexit, a recent survey by Procure Partnerships (2021) indicates that 90% of businesses have faced disruption since the end of the transition period, and 76% had their Brexit response disrupted by Covid-19. As a result, the UK's construction industry procurement methods are undergoing vast transformation, forcing companies to re-evaluate their supply chains, ensuring they are resilient and enforce ‘future proofing’ supply chains (Procure Partnerships 2021).

Miroudot (2020) identifies Covid-19 as one of the disruption factors in global supply chains based on the vulnerabilities within international production networks. Magableh (2021) identifies nine factors in supply chains: disruptions, cost control, capability building, aspects, facts, phenomena, areas of enhancement, steps toward supply chain stability, and continuous development. In addition, Magableh (2021) established three longevity categories for supply chain (SC) disruptions as a result of COVID-19: short, medium, and long-term disruptions. Whilst each stage has its unique characteristics, Magableh (2021) highlights the interconnection between each stage, stating ‘SC decision-makers and managers must consider the disruptions, consequences, and solutions of each stage carefully, suggesting organisations should first focus on short-term solutions and management to recover and enable the continuity of flows.

Cherian and Arun (2022) indicate that during the uncertainty period, the companies were unprepared to meet the risk, unable to reinstate the material flow, and took a long time to restore to its original state. Osunsanmi (2022) argue that the disruption

caused by Covid 19 caused weak construction supply chain activities resilience because the existing management model only focuses on preparedness and recovery, not resilience. Salami et al. (2021b) proposed some contractual dispute avoidance measures adopted by construction firms during Covid-19. The measures include maintaining a good relationship with contractual partners, a brief report of any potential for dispute, collaboration with contractual parties for goodwill, early decision on site closure, and studying contractual terms for notice period information. Magableh's (2021) studies cover abnormal interruptions in general business experience and global trade, with broad findings but not specific enough for application within the construction industry.

2.2.2 Brexit effects on supply chains disruption

A recent study by Smith et al. (2020) considers the impacts of Brexit on the UK construction industry; these include economic, political, and legal issues. RICS (2021) describes Brexit as disruptive in the construction supply chain. RICS (2021) states that the changes from Brexit will affect almost every aspect of the procurement and delivery of projects in the UK and across the EU. Without empirical work, it was suggested that the effect of Brexit will lead to short-term shortages, price increases, and increased overheads for manufacturers but should not have a long-term impact. Brexit has led to additional administrative and due diligence procedures. Reduction in the availability of construction materials is another factor in a toxic mix. In a study on the social housing supply chain and Brexit, Linton (2018) identified key issues that are likely to cause disruptions in finance, materials availability, logistics problems, people/stakeholders, information/technology, and infrastructure. On supplier relations, the CIP (2022) postulates that supply chain delays, longer delivery times, and warehousing times are increasing organisations' costs which might lead to financial stress. After Brexit and the Covid-19 pandemic, there is an increased risk of labour exploitation in the UK (Walsh et al., 2022). The CIP (2022) record surges in the price of timber, bricks, and steel which they believe is attributable to the combined impact of Brexit and the pandemic, causing supplies to be held up on their way to the UK.

2.2.3 Conceptual framework

The conceptual framework brings together the relationship between key areas of study, the effect of Covid 19, Brexit and supply chain disruption as previously discussed. Figure 1 presents the conceptual framework, the relationship between the expected causes, expected effects, and mediating variables. The conceptual framework shows the research design/process and maps out the relationships to draw a coherent conclusion. The independent variable (expected cause) consists of two predictors, Covid 19 and Brexit. The expected effect, supply chain disruption, is the dependent variable (the outcome variable). The hypothesis, therefore, is that the effects of Covid-19 and Brexit (short, medium, and long-term) lead to a disruptive construction supply chain. The mediating variables link the independent and dependent variables, making the relationships better understood. Twelve key supply chain factors serve as mediating variables.

Insert Figure 1 Conceptual framework

3. METHODOLOGY

The study relies on different research tools and is associated with positivist and interpretive research philosophy. Smyth and Morris (2007) postulate that positivism, in its various forms, creates closed cause-effect models, relies on deduction and pursues generalisations to establish principles or laws to govern its object. The hard paradigm, which is often associated with rigour and objectivity, is also commonly associated with a positivist epistemology, deductive reasoning and quantitative or reductionist techniques. Conversely, the soft paradigm is commonly associated with interpretive epistemology, inductive reasoning, and exploratory, qualitative techniques, which emphasise contextual relevance rather than objectivity (Pollack, 2007). The deductive method is also used to explain causal relationships between concepts and variables, measure concepts quantitatively and generalise research findings. The ontological position of the positivist approach is realism, and the interpretive approach relies on relativist ontology in this study. The research paradigm relied upon in this study are positivism and interpretivism. Positivism allow building causal relationships by ranking the factors through quantitative approaches and interpretivism enable to have opinions from different social realities through focus group exercise and interviews.

The study used a mixed-method sequential explanatory design characterised by the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data. The aim is to use qualitative results to assist in explaining and interpreting the findings of a quantitative study (Creswell & Clark, 2011). Quantitative and qualitative can help improve confidence in the findings, supplying more evidence while counteracting potential shortcomings from using the single-method approach (Caruth, 2013). The findings from qualitative research can aid in enriching and contextualising the quantitative findings and increasing the validity when understanding the data (Creswell & Clark, 2011). The data collection methods used for this study consisted of three instruments: focus group discussion, online questionnaires survey (quantitative data), and interviews. The online questionnaires were distributed using convenience and linear snowball sampling techniques. This focused on participants who are construction professionals and work for SMEs.

The focus group approach is used to gather diverse experts' perspectives and opinions on the most important factors to evaluate the combined effects of Covid-19 and Brexit on the supply chain in the UK. Hennink (2014) states, "the purpose of a focus group is to gather perspectives". After the literature review, a focus group selected a combined factor that affects Brexit and the Covid-19 pandemic. Morgan et al. (1998) focus group procedures are relied on in this study. One of the authors moderated the focus groups exercise of four SME members. Twelve factors were chosen for the study based on the following:

- (i) general perception of the supply chain
- (ii) supply chain stakeholder interaction
- (iii) effects of on-site labour shortages
- (iv) effects of office staff shortages
- (v) impact of material cost increase
- (vi) supplier's impact

- (vii) increase in labour expenditure
- (viii) time delays
- (ix) logistics and haulage delay
- (x) logistics cost increase
- (xi) relationship issues and
- (xii) communication issues.

The study's design is to have the same supply chain main factors for Covid 19 and Brexit to allow cross-comparisons of the data sets to identify the most significant impacts on SMEs across two unprecedented events. The factors were used in the questionnaire survey to rank their importance.

Table 1 presents the respondent's company's demographic characteristics and general practices. It covers the participant's current job role, sector, nature of company work, age group, year of experience and basic questions on general supply chain practices. The SMEs falls within micro and small SMEs with 0-9 and 10-49 employees and up to 2 million and 10 million pounds annual revenue respectfully. Forty-one participants responded to the online questionnaire; 39% were quantity surveyors and estimators, 34% were in construction operations (project/site/contracts managers), 17% were directors, and 10% were in design development (architect, structural engineer, civil engineer). 41% work for sub-contractors and 34% for main contractors. Fifty-one per cent of the respondents use an established supply chain practice, with 56 per cent having a designated supply chain manager. Seventy-one per cent have existing supply chain practices at work, and 61% do not use a supply chain ranking system for suppliers, subs and contractors. 78% of the companies assess and review performance; 66% use Information technology to manage supply chains; 78% of companies do not offer rewards for good and consistent performance within their supply chain. Finally, most respondents (56%) stated they had not had problems within their supply chain before Covid-19 and Brexit.

Insert Table 1 Respondents' demographic characteristics and supply chain practices

The respondents were asked about the disrupting effects of Covid-19 and Brexit on their supply chain. This data was collected using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The data was then extracted and analysed using relative importance indices (RII). This study aligns with Oyegoke et al. (2022) and Oyegoke and Al Kiyumi (2017):

$$\text{Relative Importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Relative Importance Indices formula (RII), where:

W = the weight given to each factor by the respondents ranges from 1 to 5 (where "1" is "lowest" and "5" is "highest");

A = highest weight which is 5 in this study; and

N = total number of respondents
The relative range = 0.80.

The overall longevity effects of the factors in the short, medium and long term on the Covid-19 pandemic and Brexit are also assessed and analysed through percentage frequency distribution. This method effectively expresses the relative frequency of survey responses. Semi-structured interviews were conducted over the phone, recorded, and transcribed. The interview was performed using the convenience sampling technique, with five participants working with SMEs/contractors. The interviewees are in different job roles, from contract managers, senior quantity surveyors, and managing directors with 5 -25 years of experience. The interviewees worked for main and subcontracting companies in fit-outs and refurbishment schemes, in the leisure and commercial sector, domestic, commercial mainly in supermarkets, retail, and specialists in plumbing and electricity. It takes about 30 minutes to complete each interview and the data is analysed through thematic content analysis. Burns (1997) suggests that an interview is undertaken to allow the researcher to elicit opinions, beliefs, or information from the participants.

4. DATA ANALYSIS AND FINDINGS

4.1 Supply Chain Disruption

Table 2 presents the ranking of all the 12 factors regarding the Covid-19 pandemic, Brexit, the combined effects, and the overall ranking of both covid 19 and Brexits on supply chain disruptions.

Insert Table 2: Covid-19 and Brexit Supply Chain Disruption Factors RII Analysis Index

4.2 The effects of Covid-19 on supply chain disruption

Table 2 indicates that the respondents strongly agree that material cost increases throughout Covid-19 due to supply management issues significantly impacting their company's operation. Material cost increases ranked first (RII = 0.863), followed by increases in logistical costs with the impact of (RII = 0.834). The supply chain interaction was also disrupted and ranked 2nd during the period, with an RII of 0.834. time delays were ranked 4th with RII 0.820, and logistics and haulage delays ranked 5th with RII 0.805. The three factors with the least disruptive impacts are relationship issues, RII 0.639, office staff shortages RII 0.639, and a decrease in communication with their supply chain members (RII = 0.561).

Table 3 shows that the impacts are primarily short-term. 66% of the respondents agreed that on-site labour shortages have a short-term effect on the supply chain

disruption during covid-19. Other short-term effects are logistics & haulage delay of 52%, logistics cost increase of 50%, and negative effects based on the perception of 45%. 55% of the respondents believed that supply chain interaction has medium-term effects. There is a close and divided view that labour expenditure and time delay have short and medium-term effects on supply chain disruption. 33% of the respondents believed that an increase in labour expenditure is short-term, and 30% thought it has a medium-term impact. Change of suppliers has no effect with 31%, with a short-term effect of 42%. Office staff shortages have 55% short-term effects and 41% no effects. The highest-ranked long-term effect was an increase in materials prices at 53.58%. Over half of the respondents believe the rise in material prices will be a long-term issue.

Insert: Table 3: Covid-19 Supply Chain Disruption Longevity Effects

4.3 The effects of Brexit on supply chain disruption

Table 2 shows that the ranking factor that will disrupt the supply chain based on Brexit is the interaction between the supply chain members (RII = 0.776). The material cost increase with (RII = 0.766) is the second most highly ranked. This is followed by logistics and haulage delay with RII 0.717. The three factors that will cause the least impacts are office staff shortages, RII 0.449, communication issues RII 0.493 and relationship issues RII 0.546.

Table 4 shows the percentage distribution of the longevity effects of Brexit on supply chain disruption. There is a divergent opinion on the impact of negative perception. 38% of the respondents believed there is no effect, 24% thought it is medium term, 21% short term, and 17% believed it would have a long-term impact. The close divergent view can also be seen in supply chain interaction, Logistics & haulage, delay and logistics cost increase. Although the majority of the respondents, 37% and 33%, one-third believed that logistics cost increase and logistics & haulage delays have a medium-term impact on supply chain disruption. The majority of 35% also believed that supply chain interaction has long-term effects. The respondents believed strongly, with over 88%, that there would be no effects on the office staff shortages and communication between supply chain members. 70% of the respondents believed that Brexit would not affect relationships, and 65% thought it would not affect on-site labour shortages. 59% and 58% of the respondents believed that Brexit would have no effect on the change of suppliers and increase labour expenditure, respectively. Only on the material cost increase that 48% thought it has a long-term impact.

Insert Table 4: Brexit Supply Chain Disruption Longevity effects

4.4 The combined effects of Covid-19 and Brexit on supply chain disruption

The Brexit data correlates with the Covid-19 longevity analysis, where material increases will take the longest to resolve, causing prolonged financial disruption and the overall effects on SMEs interaction. Looking at the combined effect in Table 2, the increase in material cost ranked first with RII 0.815, followed by supply chain interaction RII 0.80, logistics and haulage delay RII 0.761 and logistics cost increase RII 0.754. Relationships between stakeholders (RII 0.593), office staff shortages (RII 0.539) and communication issues (RII 0.527) are the least factors that will cause disruptions.

5. DISCUSSION

5.1 Effects of COVID-19 on supply chains

5.1.1 Material price increases

A key effect of COVID-19 on supply chain disruptions for SMEs identified in the quantitative data is material price increases. Notably, this was the most significant variable with RII 0.863. The interview participants also supported the finding and agreed that material increases had a detrimental effect on profit margins and work streams. Participant A states,

"We pay more now for materials, and a lot of the clients we work for are on a schedule of rates, and a lot of these rates were not increased to reflect the changes."

A need for flexibility in working relationships is highlighted to help in mediating problems occurring from Covid-19. In addition, participant B, with over 40 years of industry experience, commented,

"We have the biggest building boom in my lifetime", suggesting a potential additional cause of such material increases.

Participant C contextualised this:

"I would say the main concern was supply, not necessarily cost. However, as demand rose and supply reduced, the cost increased, which was just invertible. So yeah, Covid-19 affected material prices, and it continues to do so because we are still in an industry where materials are very much in great demand."

This statement further highlights one of the perceived root causes of the material cost increases; supply and demand issues, which have a knock-on effect on prices. Magableh (2021) acknowledges the impact of COVID-19 on increases based on the effect of demand and supply and its effect specifically towards the end of the supply chain, SMEs and clients. ONS (2021b) states that the coronavirus (COVID-19) pandemic has also contributed to rising steel prices due to the rise in shipping costs (paywall). The supply chain issues have affected the price of construction materials.

Due to instability on the supply side, costs cannot be confirmed. As a result, SMEs have to amend their contractual terms to reflect such instability and uncertainty within supply chains: Participant D sheds light on how the practice has changed.

"Before Covid-19 & Brexit and all the instability and price hikes within the industry, we put 'valid for 90 days on our quotations and tenders. We have amended it to the right to amend to quotation daily if there is another price hike".

61% of the respondents to the questionnaire do not use supply chain ranking systems for suppliers and subcontractors. This could suggest a potential reason why the "price hikes" were so significant to SMEs that do not have an accredited supply chain with established good working relationships. 54% believed that the increase in material cost would be a long-term effect.

5.1.2 Logistics and Haulage cost increases

Logistics cost increases were ranked second with RII 0.834, and Logistics & haulage delays ranked 5th with RII 0.805. The participants agree that these increases have significantly impacted the supply chain within their workplace. Participant B implied that their work's logistics and haulage costs were not unique to the construction section alone.

"Everyone has increased their prices for haulage and deliveries",

This amplifies the large-scale effect of COVID-19 for everyone. Participant C highlighted the potential cause for the increases by stating,

"Haulage cost has gone up; however, that is down to other factors such as oil and gas prices".

Apart from the increase in oil and gas prices, the Government's legislation prohibiting red diesel impacted the industry's supply and demand of petrol and diesel. Participant D expanded on this topic, stating,

"Potentially, during Covid, very few people were using oil and fuel, so they reduced production, now that is increased again, production is struggling to keep up and is slower, so possibly that might be contributing to the increase in fuel price".

Therefore, it could be concluded that the increase in haulage and logistics costs occurred through multiple factors in addition to COVID-19. The logistics cost increase and logistics and haulage delay are both predicted by 50% and 52%, respectively, to have a short-term effect from the Covid-19 point of view.

5.1.3 Supply chains disruption

The supply chain interaction ranked second with RII 0.834 because the supply chain is slow to react to problems when they occur. 55% believed that it has a medium-term effect. One of the interviewees linked it to the fragmentation of the supply chain process.

"It is a major factor because of the linear supply chain process; when problems occur, it gets passed down the line to us."

Vrijhoef and Koskela (2000) acknowledged the construction industry supply chain as a linear process. A significant negative effect of being unable to fulfil material and labour requirements was raised. One of the interviewees said that.

"It massively affected us procuring materials and labour throughout Covid19."

The on-site labour shortage is RII 0.790, and 66% believed that the on-site labour shortage would have a short-term effect. Another significant disruption was lead time for material ordered and subcontractor availability. Efficiency was affected due to imposed restrictions by the government (UK Government 2021) on the construction sector, which limited operatives in work areas, resulting in programme delays. During this period, limits were also imposed on the material purchased from suppliers and merchants. One of the interviewee's states

"We had working restrictions, for example, only allowed so many men on site so many meters between each other, so, this makes things difficult to work, and material restriction from merchants."

The discrimination between different categories of contracting firms was echoed by one of the participants. The upstream of a supply chain is the most critical point in a supply chain exposed to disruptions (Bode & Wagner, 2015). The company's size becomes an important factor in purchasing the needed materials. The larger companies with greater financial backing had more leverage than the SMEs. This was attested to by one of the interviewees.

"If you are not a major tier 1 contractor, potentially doing £200-300 million per year, that affects your expenditure to suppliers and subcontractors alike; it makes it hard to demand those suppliers treat you as a priority."

5.1.4 Time Delays

Time delays are ranked fourth with RII 0.820. 56% of the respondents had not endured any supply chain issues before Covid-19 and Brexit. Participant C commented on the company's unprecedented delays due to COVID-19.

"We had delays on jobs where material supply has been hugely delayed; instead of 2–3-week lead time, we were then looking at 8–9-week lead times on certain elements that were already programmed in, brickwork, for example, 12-16 weeks sometimes."

A potential cause of delays is detailed by participant A

"We are developing many houses in the UK daily; manufacturers are over-capacitated and cannot keep up with the demand."

This shows that other external factors responsible for time delays, such as large-scale residential developments and infrastructure projects, are taking a disproportionate amount of resources. Multiple participants expressed a need for better communication. Participant A stated that...

"the company felt "blindsided" by the sudden increase in delays due to little communication and lack of explanation as to issues encountered", thus leading to significant project disruption and further cost implications for the SME."

Collaborative working is a topic of increased interest in SCM practices, specifically in the construction industry. Cooper and Ellram (1993) supported by Vrijhoef and Koskela (2000), suggest that SCM should consider the entire supply chain instead of singular and modular levels.

5.2 Effects of Brexit on Supply chains

5.2.1 Material increases

Unsurprisingly material price increases were one of the leading causes of disruption within supply chains; one interviewee expressed an alternative view, implying that Brexit was not solely responsible for the material increases by stating, "when it goes up, it applies to the world economy, it does not discriminate". This supports the literature of Holcomb (2009), Wang et al. (2018), and Christopher & Peck (2004) in calling for supply chains' need for stronger resilience as they identify possibilities of multiple disruptions occurring at the same time. Additionally, another interviewee acknowledged that not much can be done about some aspects of cost increases but did suggest a means to understand and communicate the increase in material cost to the clients.

"I think better communication with suppliers would help, we do get an email to notify us, but there are no explanations with that."

The interviewees highlight the reoccurring theme of intercommunications needed for supply chains within the construction industry to work effectively and help to mitigate the effects of disruptions. The sub-themes that emerged from Brexit's effects on the supply chain is the global market effect on construction materials. Material prices went up worldwide; it was not an isolated issue in the UK, according to one of the participants. The participant acknowledged that the material prices increased, but it was due to global effects, not necessarily due to Brexit.

"when it goes up, it applies to the world economy; it does not discriminate."

Another participant stated that

"A lot of the materials we get are not from European countries, so all the metal works and so on come from China. So, Brexit did not have any major impacts on our stream of materials, potentially short-term."

Poor communication is another sub-theme from the suppliers and manufacturers to the SMEs. Clarity was pointed out as one of the problems.

"I think better communication is important too; we get an email to notify us, but there is no explanation."

According to Golan et al. (2020), it is important to understand how materials move physically between nodes in a supply chain network for uninterrupted operations, especially during a pandemic, when physical contact between humans and materials alike exacerbates the risk of spreading disease.

5.2.2 Logistics and haulage delays

Another factor identified for causing significant disruption was logistics and haulage delays; participant D states, "we had major delays from things overseas" another

participant cited importing issues by saying, "it has increased lead times, issues associated with imports". In contrast, several interviewees experienced insignificant disruptions due to sourcing materials and labour within the UK. Although disruption within the UK might be insignificant compared to materials from overseas. One of the participants also acknowledged that

"There was a problem with many European drivers returning now; that becomes a problem with the haulage sector in general".

This shows the need to diversify supply chains and establish new relationships with suppliers to ensure lead times and project programmes are achieved to discourage the effects of an adverse event such as Brexit.

5.2.3 Supply chain disruptions

According to Altay *et al.* (2018), effective collaboration, transparency, accountability and stakeholder relationship are vital for SC performance during an uncertain situation. Participant A stated, "I would say it is more short-term while building relationships with other suppliers and subcontractors, so we are now sourcing from the UK instead." This highlights the need for good working relationships and collaboration with suppliers due to the risk-prone nature of sourcing on an international scale.

Lack of proper supply chain interaction and poor communication also led to delays as most SMEs are caught out by the sudden increases with no justification. A participant said

"You might get a short warning from the merchants that things are going up, but you do not often. I sometimes feel blindsided by them." "Some of our subcontractors use European labour, which affected us indirectly."

Labour shortages have no longevity effect; this could be down to several factors; the participant companies might not have relied on European labour, resulting in no longevity effect. This was apparent as an interviewee explained the reasoning behind it due to limited reliance on using European labour; participant C contextualised this by saying,

"We tend only to have permanent employment, whereas some of our subcontractors might use European labour, so maybe it did affect us indirectly, but it is almost managed outside of our orbit and is usually dealt with before being a problem."

It could be argued that the longevity of this effect could be different depending on the source of material and labour; in this case, sourcing these within the UK proved beneficial for the interviewees and a potential solution to mitigating longevity effects, opting for local labour source and materials where possible. The last longevity Brexit factor that has a short-term effect is logistics and haulage delays; this is evidenced as one interviewee speculates,

"There was a problem with many European drivers returning home that became a general problem within the haulage sector; we had a fake fuel hike because of those haulage issues; I think it is a short-term issue."

The longevity of the effect of Brexit on construction supply chains identified in this research supports that of the RICS (2021) article, determining that Brexit was deemed to cause disruptions, the majority of which were short-term effects.

The combined effect of covid and Brexit is another issue raised by one of the participants.

"It is difficult to say because covid -19 has shadowed the situation. The thought process before covid-19 was that Brexit would affect it, and there has been a short-term effect to a certain degree where we have had to order from a different continent. It has increased the lead times due to issues associated with imports, etc., but that is far and few between."

5.3 Disruption mitigation framework'

The disruption mitigation framework is developed from the ranking of key disruptive events. The disruptive events under consideration are Covid-19 and Brexit. Figure 2 presents the most disruptive factors with their longevity effects and mitigating solutions. An increase in material and logistical costs, supply chain interaction, and time delays were identified as factors with the most impacts on supply chain disruption during Covid 19. They have long-term, medium-term, and short-term effects, respectively. However, the factors with the least disruptive impacts are relationship issues, office staff shortages, and a decrease in communication with their supply chain members. Most of the factors have a short-term effect in disrupting the supply chain. Interaction between the supply chain members, the material cost increase in logistics, and haulage delay are the significant factors that disrupted the supply chain due to Brexit. The first two factors have long-term effects, and the logistics and haulage delays have a medium impact, as shown in Figure 2. Over 88% thought Brexit would not affect office staff shortages and communication between supply chain members.

Insert Figure 2 SMEs disruptive factors, longevity effects and mitigating measures

About half of the participants in the study did not have a supply chain framework in their workplace or a designated supply chain manager. This suggests a lack of structure and organisation in the supply chain process resulting in the inability to manage and coordinate the supply chain efficiently. The participants suggested solutions to these problems by having a supply chain framework. This will enable the SMEs to adhere to the best practice when selecting their supply chain members. As one participant put it, the supply chain framework should be resilient to external forces because *"problems can always occur; it depends on the size and severity of the problems and the resilience needed to overcome them"*. Another participant states, *"I would say you always have supply chain issues; it is just about how big and manageable the problems are"*.

Creating an environment that delivers through a network of good intercommunication between the supply chain process is essential. One of the participants suggested that

partnering arrangements might play a positive role *“back to having those partnering arrangements with suppliers and getting early notice and communication from them when the issues are about to occur”*. The framework should also include relationship building between suppliers and sub-contractors; a participant said, *“I think the essential element to any supply chain success is on time and in harmony by having good working relationships”*. Flexibility is also essential; as one participant put it, *“from our experience, being flexible as possible in your approach has worked well with our supply chain”*. Collaborative working practice is also suggested as an effective way to manage the supply chain. Building resilience in the system will prevent a repeat of disruption during a pandemic or time of peril. This aligns with CIP (2022), building resilience in the supply chain. All the participants expressed willingness to adopt a framework if proven beneficial.

6. CONCLUSIONS

The UK construction industry has encountered a series of problems based on the economic uncertainty of Brexit with a combined effect of the Covid-19 pandemic. This has disrupted the supply chain, affected the haulage sector, shortages in drivers, caused increased delays and scarcity of materials, and threatened to put a brake on UK growth. The study examines the impacts of Covid-19 and Brexit on supply chain disruption in the construction industry from the SMEs' perspective. The paper presents the two main results of covid 19 and Brexit supply chain disruptive factors and their longevity effects in the short, medium, and long-term. The impact of Covid 19 disruption leads to increase in material cost, logistics cost, and supply chain interaction with long-term, medium-term, and short-term longevity effects, respectively. The impact of Covid 19 was minimal on the communication, staff shortages, and on relationships among the stakeholders. The Brexit disruptive factors include supply chain interaction and material cost increase which have long-term longevity effects and haulage delays with a medium-term longevity effect. There was a minimal impact on office staff shortages, communication and relationship issues. The combination of both Covid 19 and Brexit indicate an overall impact on material cost increase, supply chain interaction and logistic and haulage delay.

Some of the solutions suggested to mitigate the disruption are a collaborative way of working, greater transparency, working flexibility, building resilience in the system, and a good working relationship between supply chain stakeholders. Through the identification and ranking of disruptive factors, a framework is suggested. This will help the government and the SMEs to manage future/similar external events affecting the supply chain. Potential future research could investigate the adoption of SCM technologies and their effectiveness in implementation during pandemic and special events like Brexit.

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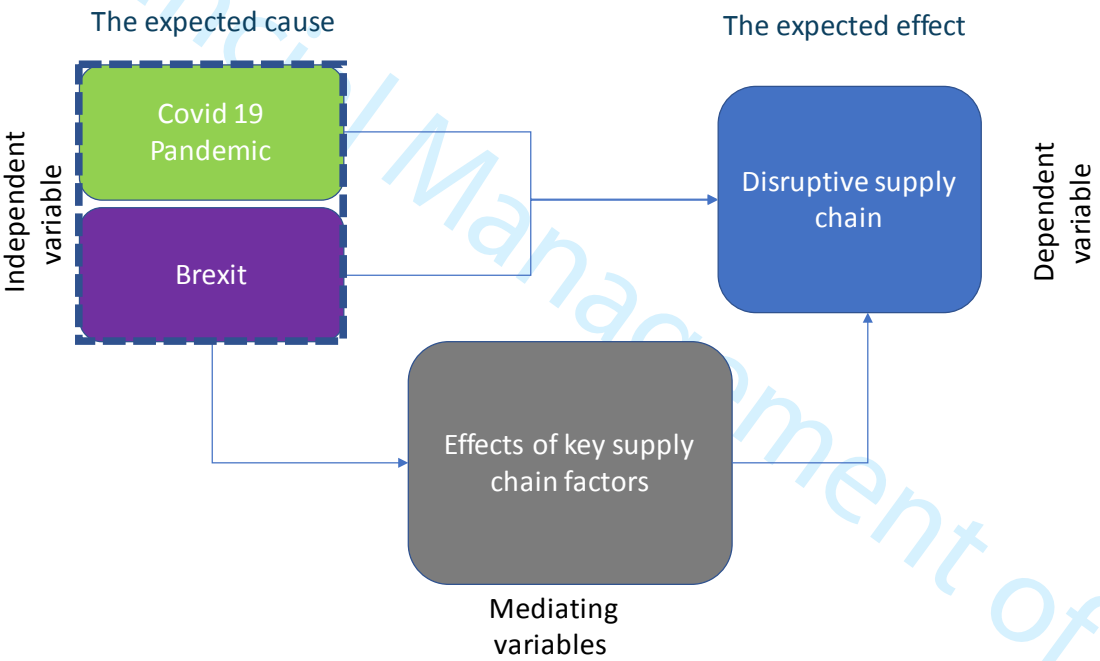
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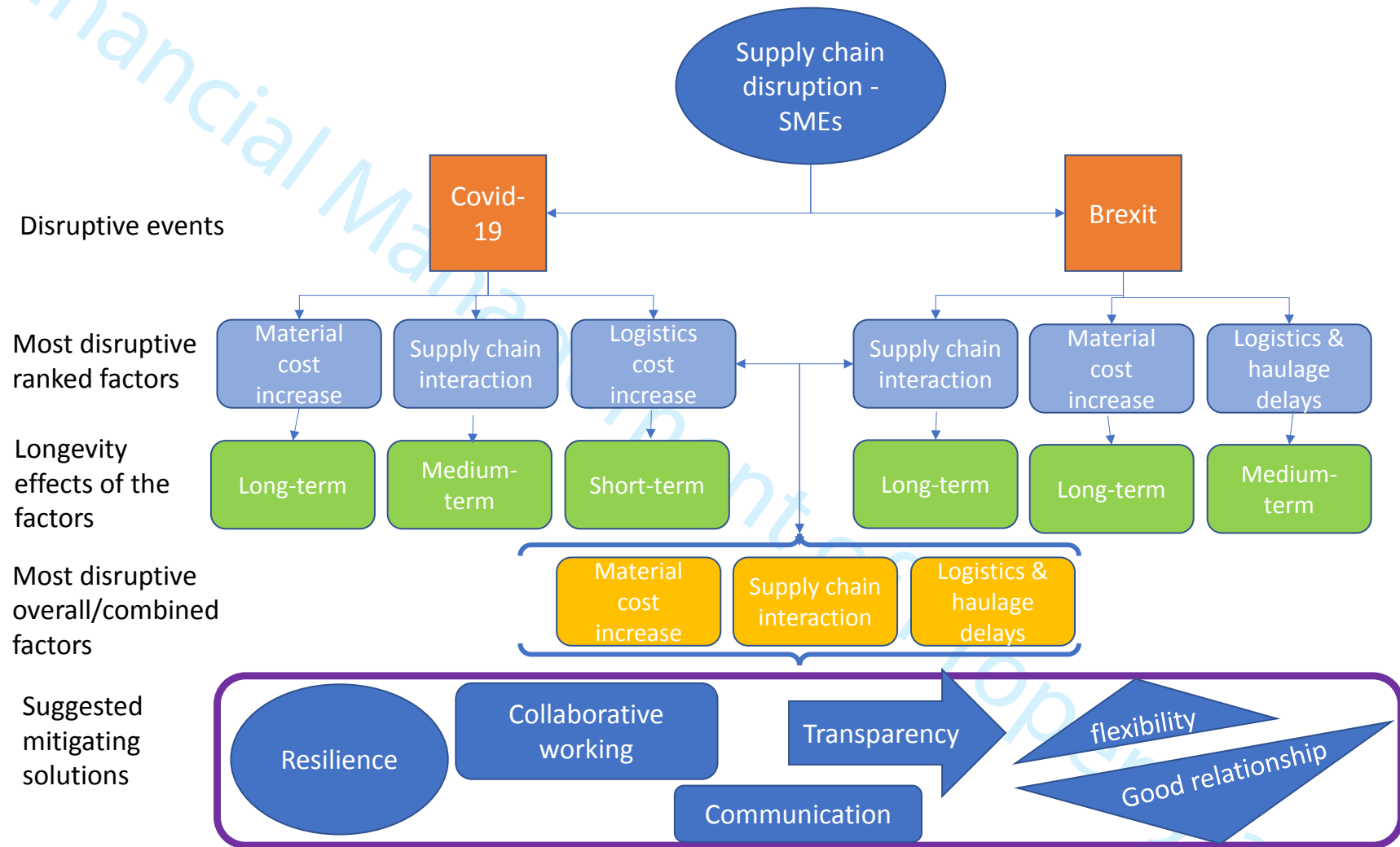
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Insert Figure 1 Conceptual framework

Source: Author's own creation



Insert Figure 2 SMEs disruptive factors, longevity effects and mitigating measures

Source: Author's own creation

Table 1 Respondents' demographic characteristics and supply chain practices

Demographic characteristics of the participants (41)		Frequency	%tage
Current job role	Director	7	17%
	Operations (project, site and contract manager)	14	34%
	Commercial (quantity surveyor, estimator, buyer)	16	39%
	Design (Architect, engineers)	4	10%
Nature of company work	Client	1	2%
	Main contractor	14	34%
	Sub-contractor	17	41%
	Supplier	5	12%
	Consultant	4	10%
Sector within construction	Domestic/residential building	4	10%
	Commercial building	20	49%
	Industrial building	3	7%
	Civil and infrastructure	3	7%
	All of the above	11	27%
The age group of participants	16-24	5	12%
	25-35	13	32%
	36-45	11	27%
	46-55	11	27%
	56-65	1	2%
	66+	0	0%
Years of experience in the construction industry	<1 year	1	2%
	1-5 years	5	12%
	6-20years	25	61%
	21-30 years	3	7%
	30years +	7	17%
Supply chain framework/practices within the current role:		Yes	No
Using a supply chain management framework at your work		21 (51%)	20 (49%)
Having a designated manager dealing with the supply chain		23 (56%)	18 (44%)
Known supply chain management practice at your work		32 (78%)	9 (22%)
Use of classification ranking system for selecting suppliers		16 (39%)	25 (61%)
Review of supply chain performance		32 (78%)	9 (22%)
The use of IT to manage the supply chain		27 (66%)	14 (34%)
Incentives to the suppliers by your company		9 (22%)	32 (78%)
Problem with suppliers prior to Covid 19 and Brexit		18 (44%)	23 (56%)

Source: Author's own creation

Table 2: Covid-19 and Brexit Supply Chain Disruption Factors RII Analysis Index

	Covid-19		Brexit		Combined effects	Overall ranking
	RII	Ranking	RII	Ranking		
The negative effect (perception)	0.790	6	0.668	5	0.729	6
Supply chain interaction	0.834	2	0.776	1	0.805	2
On-site labour shortages	0.790	6	0.610	8	0.700	7
Office staff shortages	0.629	11	0.449	12	0.539	11
Material cost increase	0.863	1	0.766	2	0.815	1
Change of suppliers	0.643	9	0.576	9	0.610	9
Labour expenditure increase	0.760	8	0.634	7	0.697	8
Time delays	0.820	4	0.668	5	0.744	5
Logistics & haulage delay	0.805	5	0.717	3	0.761	3
Logistics cost increase	0.834	2	0.673	4	0.754	4
Relationship issues	0.639	10	0.546	10	0.593	10
Communication issues	0.561	12	0.493	11	0.527	12

Source: Author's own creation

Table 3: Covid-19 Supply Chain Disruption Longevity Effects

Covid 19	No effects	Short term	Medium-term	Long-term	Total
The negative effect (perception)	9.70%	45.10%	29%	16.10%	100%
Supply chain interaction	0%	29%	54.80%	16.10%	100%
On-site labour shortages	13.78%	65.53%	20.68%	0%	100%
Office staff shortages	41.38%	55.18%	0%	3.44%	100%
Material cost increase	7.14%	10.71%	28.57%	53.58%	100%
Change of suppliers	30.77%	42.32%	11.53%	15.38%	100%
Labour expenditure increase	14.18%	33.33%	30.27%	22.22%	100%
Time delays	7.14%	42.75%	46.43%	3.58%	100%
Logistics & haulage delay	6.46%	51.61%	32.26%	9.67%	100%
Logistics cost increase	3.57%	50%	35.71%	10.72%	100%
Relationship issues	66.6%	14.81%	11.11%	7.41%	100%
Communication issues	67.85%	17.86%	3,57%	10.72%	100%

Source: Author's own creation

Table 4: Brexit Supply Chain Disruption Longevity effects

Brexit	No effects	Short term	Medium-term	Long-term	Total
The negative effect (perception)	37.94%	20.69%	24.13%	17.24%	100%
Supply chain interaction	19.23%	19.23%	26.92%	34.62%	100%
On-site labour shortages	65.36%	15.38%	7.70%	11.53%	100%
Office staff shortages	88.46%	3.84%	7.70%	0%	100%
Material cost increase	18.51%	11.11%	22.22%	48.14%	100%
Change of suppliers	57.69%	7.70%	7.70%	26.92%	100%
Labour expenditure increase	59.25%	7.41%	14.81%	18.51%	100%
Time delays	33.33%	14.81%	33.33%	18.51%	100%
Logistics & haulage delay	25.92%	25.92%	33.33%	14.81%	100%
Logistics cost increase	22.22%	18.51%	37.03%	22.22%	100%
Relationship issues	70.3%	7.40%	7.40%	14.81%	100%
Communication issues	88.88%	0%	11.11%	0%	100%

Source: Author's own creation