

# A conceptual framework for understanding resilience of construction SMEs to extreme weather events

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## Abstract

### Purpose

Small and Medium-sized Enterprises (SMEs), which form a significant portion in many economies, are some of the most vulnerable to the impact of Extreme Weather Events (EWEs). This is of particular importance to the construction industry, as an overarching majority of construction companies are SMEs who account for the majority of employment and income generation within the industry. In the UK, previous research has identified construction SMEs as some of the worst affected by EWEs.

### Design

Given the recent occurrences of EWEs and predictions suggesting increases in both the intensity and frequency of EWEs in the future, improving the resilience of construction SMEs is vital for achieving a resilient construction industry. A conceptual framework is first developed which is then populated and expanded based on empirical evidence. Positioned within a pragmatic research philosophy, case study research strategy was adopted as the overall research strategy in undertaking this investigation.

### Findings

Based on the findings of two in-depth case studies of construction SMEs, a conceptual framework was developed to represent EWE resilience of these construction SMEs, where resilience was seen as a collective effect of vulnerability, coping strategies and coping capacities of SMEs, characteristics of the EWE and the wider economic climate.

### Originality/value

The paper provides an original contribution towards the overarching agenda of the resilience of SMEs, and policy making in the area of EWE risk management by presenting a novel conceptual framework depicting the resilience of medium-sized construction companies.

**Keywords:** Business continuity, Construction, Disaster planning, Extreme Weather Events, Resilience, SMEs

**Manuscript type:** Conceptual paper

# 1 Introduction

Small and Medium-sized Enterprises (SMEs), which form a significant portion in many economies, are some of the most vulnerable to the impact of Extreme Weather Events (EWEs). In this research, EWEs are considered as “weather conditions that are rare for a particular place and/or time” (Hallet, 2013). Although the word ‘rare’ is used here, the term EWE is often used to refer to weather of sufficient severity to generate a hazard. EWEs are of particular importance to the construction industry, as an overarching majority of construction companies are SMEs who account for the majority of employment and income generation within the industry. In the UK, over 0.95million SMEs operate in the construction industry in comparison to approximately 285 large enterprises (BIS, 2014). These SMEs generate around 85% of employment and around 73% of revenue in the industry (BIS, 2014). Ensuring that SMEs are allowed to perform well, grow and develop is seen as a key factor that contributes to sustainable development in the construction sector (The Scottish Government, 2013). SMEs operating in the industry are particularly vulnerable to the impacts of EWEs, due to the inherent nature of the industry and construction SMEs.

EWEs can have both direct and indirect effects on the construction. Direct effects include disruption to site works as a consequence of the EWE itself; indirect effects include disruption to site works as a consequence of the secondary effects of an extreme weather event (e.g. due to disruptions to deliveries and utility supplies through the supply chain) (Metcalf et al., 2009). Whilst the general nature of the industry demand a higher level of activity to be resilient, evidence suggest this is not to be the case in practice. Norrington and Underwood (2008) found construction sector SMEs as the least prepared in terms of business continuity planning compared to the other industry sectors surveyed. Further, a survey of businesses operating in the Cumbria region found that a majority of businesses that have ceased business following extreme weather events in 2009 and 2010 as construction SMEs (Wiseman and Parry, 2011). 74% of businesses that have ceased trading were from construction, all of whom falling into the category of SMEs. This suggests that there is a general inertia among construction SMEs to enhance their resilience to EWEs despite their increased vulnerability.

The issue of resilience of construction SMEs to extreme weather events, however, has been the subject of limited academic research. Work by Berkhout et al (2004) remains a key study addressing this subject area. However, their study too does not specifically focus on construction SMEs or extreme weather events. Given that SMEs in the construction sector possess unique characteristics (Sexton and Barrett, 2003), relevance of studies focusing on general resilience to the context of construction SMEs is questionable. It can be argued that this lack of comprehensive understanding has also contributed towards the inertia among construction SMEs in increasing their resilience to EWEs. When taken individually they make look small in scale, however more than 90% of companies in the construction industry are SMEs. Hence, a smaller improvement in resilience at an organisational level can make a significant contribution towards industry improvement. Wedawatta et al (2010) reported the initial conceptual model for SME resilience improvement based on a comprehensive literature review. The research reported in this paper was undertaken to shed more light on further issues related to resilience of construction SMEs to EWEs; including the impacts, responses, perceptions, drivers/barriers for resilience, and support requirements. The enhanced conceptual framework proposed in the paper therefore will identify the value of focusing on SMEs in construction in generating a conceptual but a model that identifies the value of behavioural change in construction SMEs.

The paper seeks to present a novel conceptual framework developed to represent resilience of construction SMEs to extreme weather events. It builds on work previously reported by the authors

and introduces an expanded conceptual framework which is grounded within the construction SME context. Initial conceptual framework is first presented, followed by a brief discussion of the primary research method adopted to populate the initial conceptual framework. Key issues identified in relation to EWE resilience of construction SMEs are then discussed. Following this, the expanded/populated framework which illustrates the resilience of case study construction SMEs is introduced. This novel conceptual framework is an original attempt to represent resilience of construction SMEs specifically, as little research has been undertaken to date to study the resilience of construction SMEs specifically as opposed to SMEs in general.

## 2 Initial conceptual framework

Resilience, from an organisational context, has been defined in different ways by different researchers. Somers (2009) assessed the broad range of resilience definitions found in organisational theory, and found that they range from definitions focussing on passive approaches such as bouncing back from disruptive events and absorbing disruptions to active approaches aimed at improving capacity to cope with disruptive events. Many of the recent definitions of organisational resilience embrace the notion of active resilience in a dynamic environment. McManus et al (2007) identified resilience as a function of an organisation's situation awareness, management of keystone vulnerabilities, and adaptive capacity in a complex, dynamic and interconnected environment. Linnenluecke and Griffiths (2010) argued that capabilities that enable organisations to prepare for EWEs and different response and operational strategies to minimise the impact and to facilitate recovery and reorganisation as key to achieving organisational resilience. Accordingly, organisational capabilities and strategies were thought to be key elements of resilience. Elwood (2009) recognised that resilience incorporates the notion of a living organism, able to adapt and respond to changing environments and overcome adversity. Learning lessons from different hazard events and embracing the lessons learnt are considered to be key in enhancing organisational resilience (Berkhout et al., 2004, Linnenluecke and Griffiths, 2010).

Based on extant literature and researcher's interpretation of related concepts, an initial conceptual framework was developed to represent the theoretical concepts behind what resilience is envisaged in a SME context, in relation to EWEs (See Figure 1). The conceptual framework incorporates the views of organisational resilience as put forward by the likes of McManus et al (2007) and Linnenluecke and Griffiths (2010) and general resilience as put forward by Cutter et al (2008). Cutter et al (2008) viewed the impact of an EWE on a certain entity as a cumulative effect of several key issues in addition to the characteristics of the EWE itself. The level of impact and, thereby, the level of resilience required of the SME will depend on a number of complex and interrelated issues. Accordingly, in this research resilience is seen as a collective effect of vulnerability, coping strategies and coping capacity. The initial conceptual framework specifically acknowledges the broader nature of EWE impacts that extend beyond the physical boundaries of an SME, throughout its supply chain. SMEs may experience negative impacts of EWEs due to their supply chain partners being affected by EWEs and vice versa (Metcalf et al., 2009, Zhang et al., 2009, Wedawatta et al., 2010). This interconnected business environment was reported earlier in Wedawatta et al (2010) is considered important if SMEs are to enhance their resilience to EWEs.

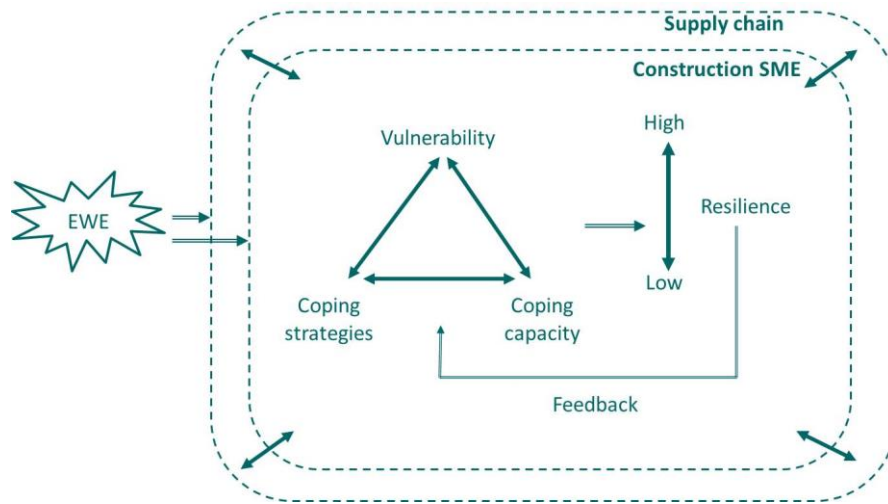


Figure 1 - Conceptual framework of the research (Wedawatta et al., 2010)

The initial conceptual framework (see Figure 1) as reported in Wedawatta et al (2010) seeks to represent factors that contribute to resilience of SMEs as opposed to representing how decisions are made in relation to resilience. Primary research sought to expand this initial conceptual framework and populate it based on evidence emerging from case studies of construction SMEs. Thereby, the study sought to develop a more developed conceptual model that will position construction SMEs as having their own unique needs amenable to kick starting more focused policy making measures. Hence the novel conceptual framework that is presented in the paper will represent resilience of construction SMEs to extreme weather events in a uniquely. This expanded conceptual framework and the process adopted will provide the blueprint to develop a rigid theoretical framework representing EWE resilience of construction SMEs.

### 3 Research method

Case study research strategy was adopted as the overall research strategy in undertaking this investigation. A mixed method research choice consisting of an exploratory questionnaire survey of SMEs and in-depth interviews of case study SMEs were employed to investigate the research questions. For a detailed discussion on the research method adopted, please see Wedawatta et al., 2010, Wedawatta and Ingirige, 2011, Wedawatta et al., 2011. Although framework development is informed by the exploratory questionnaire survey, it is primarily based on the in-depth case studies. Therefore, the case studies are briefly introduced below. Criteria for selecting case study research included compatibility with the philosophical positioning, appropriateness for investigating the research questions, satisfying the criteria for selecting case study strategy, and the ability to accommodate different research techniques (See Wedawatta et al (2011) for a detailed discussion on this).

Two in-depth case studies were developed to explore the context within which construction SME's interpret and respond to EWEs. The first case study was a building contractor (CSA) and the second a civil engineering contractor (CSB). Both SMEs are medium-sized businesses employing between 50 and 249 employees; 76 employees in CSA and 220 in CSB, and are well established construction organisations that have been in business for several decades. These two cases were selected to obtain the perspectives of both building and civil engineering construction SMEs. In each case, a construction project which had been affected by a recent EWE was studied to obtain an

understanding of on-site issues related to EWEs. The projects studied were (CSA) a residential development (CSAP) and (CSB) a land remediation and earthworks project (CSBP).

In each case, respondents from the head office as well as the site management of the selected projects were interviewed. The key criterion considered in selecting the participants was who is best placed to provide the required information. These participants are known as key informants. A key informant in the interview process is an individual who hold positions of authority and respect, within the chosen SME and are used to provide intimate knowledge and experience of the subject area (Marshall, 1996). In the case of CSA, the managing director (CSA1) and the project manager of the selected project (CSAP1) were interviewed. In the case of B, three senior managers (CSB1, CSB2, and CSB3) as well as the project manager of the selected project (CSBP1) were interviewed. In CSA, the organisational structure and the decision making responsibility within the SME meant that it is sufficient to obtain information only from CSA1, as CSA1 was directly responsible for both strategic and operational decision making. However, CSB being a much larger organisation with a more complex decision making structure; interviews were conducted with three senior management level interviewees. These personnel had responsibility for direct operational decision making within the SME. First stage of the case study interviews took the form of semi-structured interviews. Following this, extended structured interviews were conducted with the case study informants, involving multiple visits to case study organisations and sites. As part of the study, case study SMEs were investigated in detail with regard to their previous EWE experiences, impacts, risk management and resilience. The two case studies were purposively selected to adequately address the research objectives of the study. As the two case study organisations are medium-sized companies, the expanded and populated conceptual framework will primarily be applicable to medium-sized organisations. This however will provide useful insights in to the wider SME construction companies, as there are broad similarities between the micro, small and medium sized companies that form the umbrella term of 'SME'.

Data collected from the interviews were analysed using content analysis and cognitive mapping. Content analysis is a technique in which the researcher interrogates data for constructs and ideas that have been decided in advance (Easterby-Smith et al., 2008). Krippendorff (2004) identified that content analysis can take the form of word count or thematic, conceptual analysis. In conceptual content analysis the text is scrutinised to check the existence of a concept, considering terms related to the concept both implicitly and explicitly (Krippendorff, 2004). In this study, conceptual content analysis is used to analyse interview data.

As case study research is often subjected to criticism it is important that validity and reliability of case study research is established by following the tests of validity and reliability (Yin, 2003). Use of multiple sources of evidence (literature review, questionnaire survey, interviews, and document review) and interview transcripts being reviewed by the interviewees to ensure that their views were correctly recorded, were followed to ensure construct validity as proposed by Yin (2003). External validity refers to whether the findings of a particular study are generalisable beyond the immediate case study (Yin, 2003). In this research, review of key literature, relating the findings to literature, and cross-case analysis has been followed to observe construct validity. Steps including the use of case study protocol, documenting each operational stage of the research have been followed for validity of the research. In qualitative research, researcher's perceptions and world views have an impact on the research process. Hence, it may be difficult to reproduce the same results (Remenyi et al., 2003) in such research. Therefore, it is recommended demonstrating the transparency of the study through good practice guidelines, including keeping a record of activity throughout the study. Accordingly, each operational activity was documented in the research.

## **4 Factors contributing to resilience of construction SMEs**

Data were analysed to interrogate the key issues that affect the resilience of construction SMEs. Based on the findings emerging from the study, key issues that determine each component included within the conceptual framework; vulnerability, coping strategies, coping capacity, and characteristics of EWEs were identified. The following sections seek to briefly discuss the issues identified in relation to each component of the conceptual framework and how the framework was expanded to reflect the findings of the study.

### **4.1 Vulnerability**

Vulnerability in this study was identified as the characteristics and circumstances of SMEs that determine how susceptible they are to the impact of extreme weather hazards. Through analysis of the findings of the study, a number of factors can be identified as having a major influence on the vulnerability of construction SMEs. These are outlined below.

#### **4.1.1 Size of the SME**

Vulnerability is often linked with organisational size and consequently smaller businesses are often identified as more vulnerable to disruptions. Case study respondents reported that EWEs that affected their businesses had a bigger impact on smaller construction companies. Previous research has also reported vulnerability to EWEs as being strongly linked with the size of businesses and that smaller business as more vulnerable to EWEs (Runyan, 2006, Tierney, 2007). As discussed by Sullivan-Taylor and Branicki (2011), due to the impact of organisational size on the resilience capabilities of an organisation, one size of regulation or advice is unlikely to fit all business organisations. Therefore, size of a SME can be identified as an influential factor that contributes towards vulnerability to EWEs.

#### **4.1.2 Business specialisation**

The findings from the case studies established that SMEs specialising in certain trades to be more vulnerable to EWEs. This was confirmed by respondents from both the case study SMEs. For instance, CSA1 and CSAP1 highlighted that sub-contractors specialising in roofing work, ground work, and wet trades including brick work, block work and concrete work were some of the trades significantly affected by EWE disruptions. Similarly, CSB1 confirmed earthworks to be a trade significantly vulnerable to EWEs. Further it was noted that some of the construction SMEs specialising in earthworks alone have struggled following EWEs and that CSB has been able to avoid such difficulties due to it being a diverse business. Therefore, business specialisation can be identified as a factor contributing to the vulnerability of construction SMEs.

#### **4.1.3 Diversification and spread of projects**

Langdon and Male (2001) identified five reasons for diversification in construction firms; increasing profitable growth, seeking diverse activities where profitable growth can be achieved, increasing efficiency through supply chain control, use of positive cash flow, and to avoid construction cycles, particular clients and markets. The findings from this study suggest that construction SMEs have found diversification to be an effective strategy that enables them to limit the adverse impacts of EWEs on their businesses. For e.g. CSB identified that expanding beyond its core activities of earthworks and remediation, and diversifying in to other areas like demolition and recycling, aggregate supply, plant and transport etc has enabled it to be a more resilient organisation. Therefore, case study SMEs are said to be looking to further expand their diversification strategies

and achieve a greater spread of construction activities, to counteract potential adverse impacts of EWEs. Therefore, whilst diversification has evolved primarily as a commercial strategy, as identified by Langdon and Male (2001), construction SMEs seem to consider diversification as a way of enhancing their resilience to the increased risk of EWEs.

#### **4.1.4 Extent of subcontracting / individual supply chain**

The case of CSA demonstrates how its sub-contracting practices have enabled CSA to transfer some of the costs of EWEs down to its sub-contractors. This has made CSA less vulnerable to damages from EWEs. Conversely, CSB's policy of supplying all plant, labour to its projects and minimising sub-contracting has increased its vulnerability to damages in the event of an EWE. As a result of not being in a position to transfer the costs to its sub-contractors or plant suppliers, CSB was required to absorb the total cost of disruption on its own. This suggests that sub-contracting is likely to reduce vulnerability whereas having an in-house supply chain is likely to contribute towards vulnerability of a construction SME.

However, general view in literature is that sub-contracting could add to the vulnerability due to possible indirect impacts from EWEs (Zhang et al, 2009). Sub-contracting increases the probability of sub-contractors; especially those specialised in vulnerable trades, involved in the supply chain being affected by EWEs, thus creating an indirect impact on a construction SME. Further, as the literature suggests, complex supply chains with several parties further increases that risk. Therefore, it can be seen that sub-contracting practices could also increase the vulnerability of construction SMEs indirectly.

#### **4.1.5 Location of projects**

Location of business premises was not identified as a concern for construction SMEs. This is the point of departure at which construction SMEs differ from other SMEs such as those in the retail and real estate sectors. In comparison, what is of significant concern for construction SMEs is the location of their construction projects. Where the projects are and the EWEs affecting that region is likely to have a bearing on the vulnerability of a SME to EWEs. For example, CSA1 cited how weather conditions (heavy snowfall and low temperature) that affected one of the projects executed in Scotland, which were thought as extreme by CSA, were not recognised as EWEs by the client's representative as such conditions are common to the region.

### **4.2 Coping strategies**

The definition of coping strategies adopted in this study was "actions that increase the ability to prevent, tolerate and/or recover from the impacts of EWEs". Case studies revealed a number of coping strategies implemented by construction SMEs to manage the impacts of EWEs on their businesses. Some of the strategies discussed were focused at organisational level whereas others were focused at project level. Further, some of the strategies were general risk management / business continuity strategies whereas others have been specifically developed to address the risk of EWEs. Accordingly, coping strategies can be broadly categorised based on their focus; i.e. those focused at project or organisational level, and based on the risks that they seek to address; i.e. business / continuity risks in general or EWE risk specifically. This categorisation is depicted in Figure 2. A detailed discussion on this categorisation is presented in Wedawatta and Ingirige (2014).

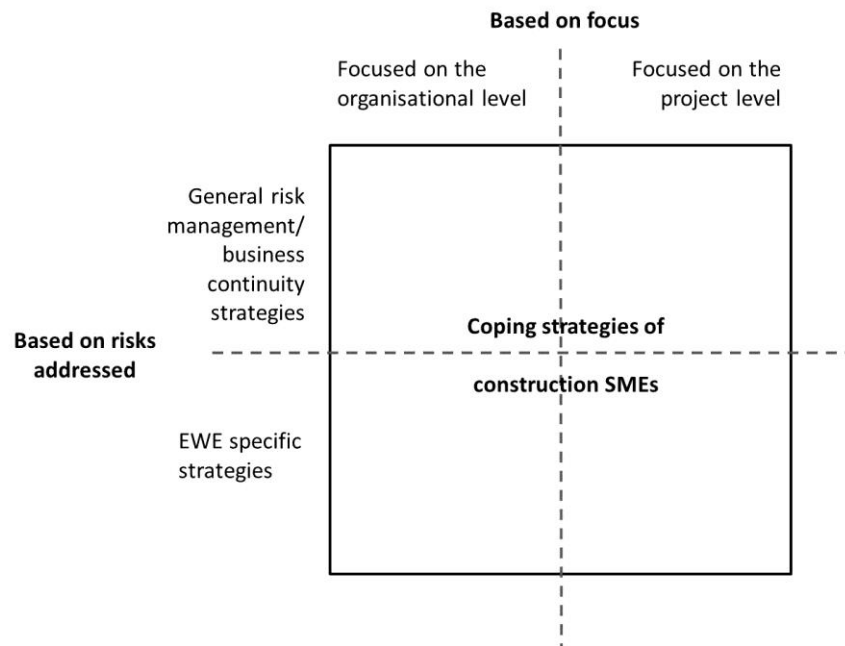


Figure 2 - Categorisation of coping strategies of construction SMEs (Wedawatta and Ingirige, 2014)

### 4.3 Coping capacity

In this study coping capacity was identified as the ability of a SME to limit the adverse consequences of extreme weather hazards, using available resources and capabilities. As noted by Linnenluecke and Griffiths (2010), to build resilience, organisations need to develop multiple capabilities and response approaches. The following sub-sections highlight some of the key factors affecting the coping capacity of a construction SME, as emerged through the findings.

#### 4.3.1 Previous EWE experience

The findings from the questionnaire survey and case study research suggested that previous EWE experience to be a key criterion that determines the coping capabilities of a construction SME. Findings confirmed that construction SMEs are likely to implement coping strategies and address the risk of EWEs within their business decision making after being affected by an EWE. Further, they were also found to be willing to investigate and invest in further strategies. Such measures that are put in place and the experience of managing the issues surrounding a previous EWE is likely to enhance the ability of a construction SME to respond to a future EWE more effectively.

#### 4.3.2 Established nature of a SME

It was noted by both construction SMEs that being an established business with a reliable track record, rapport and established relationships has aided them to withstand the adverse impacts of and recover following EWEs. The established nature of a SME leads to other aspects such as the ability to negotiate with a client (for e.g. risk sharing strategies), established client – contractor relationships (e.g. clients being sensitive to EWE disruptions to construction work, fewer disputes regarding EWEs), the ability to be selective in bidding for construction work (e.g. avoiding difficult clients, avoiding highly vulnerable projects), less impact on ability to attract projects, etc. It can be noted that these issues have contributed to the coping capacity of the two case study SMEs, due to their being well established businesses with solid track records.



### **4.3.3 Financial resources available**

Whilst the costs associated with EWE disruptions had a considerable impact on the finances of case study SMEs, they have been able to absorb these costs and manage the financial impacts due to the strong financial position of their businesses. It was noted by the case study respondents that smaller construction SMEs in a less strong financial position would not have been able to do so, and it was noted that many such construction SMEs would have closed down as a result. Resilience assessments completed following the extended interviews with case study SMEs revealed that whilst financial impacts of EWE disruption was identified as a key issue, SMEs believed that their strong financial position would contribute towards their resilience. Therefore, the ability to absorb the costs of EWEs and other financial impacts using the financial resources available to a construction SME seems to significantly contribute towards their coping capacity and thereby resilience.

### **4.3.4 Availability of expertise**

Case study SMEs recognised that expertise is required to comprehend the conditions of contract surrounding EWEs, raise claims as well as make informed bidding, pricing and project planning decisions. Even with an adequate level of expertise being available within their businesses, CSA and CSB have found it difficult to assess the conditions of contract governing EWEs and assess the risk of EWEs. It was noted that construction SMEs who do not have such expertise will struggle as a result to factor EWE risk into pricing and bidding strategies, substantiating claims, etc. Both SMEs therefore recognised their qualified workforce to be a factor that contributes towards their resilience.

### **4.3.5 Experience of senior management**

For a construction SME to arrive at a suitable resilience strategy, senior management and employees experienced in issues concerning EWEs will be required. Further, experience and perceptions of the senior management plays a crucial role in business decision making within SMEs. Norrington and Underwood (2008) noted how the perspectives and experiences of SMEs' senior management significantly drive the decision making process related to extreme weather and climate change. In a similar vein, the fact that senior management from the two case study SMEs were keen to address the risk of EWEs within their businesses have contributed towards their resilience strategy. If senior management are in denial about the risks; as is the case with many construction SMEs, such strategies might not be implemented.

## **4.4 Feedback**

It is important that lessons learned from EWE experiences are reflected in future decision making. As the evidence suggests, construction SMEs are likely to alter their way of addressing the risk once the impact of an EWE is experienced. Furthermore, vulnerabilities, effectiveness of strategies in place and coping capabilities will only become evident following the experience of an EWE. Therefore, an SME will be in a position to address the weaknesses observed in relation to an EWE by incorporating the lessons learned in relation to that EWE experience within its business planning. Therefore, the feedback loop in the framework is an important element that highlights the significance of revisiting existing strategies and incorporating lessons that can be learned from a particular EWE during the aftermath.

## **4.5 Characteristics of EWEs**

In addition to organisational factors, the characteristics of EWEs that affect SMEs also seem to contribute towards their resilience to such events. The impact that the characteristics of EWEs have on organisational resilience has been recognised in previous literature. For example, Cutter et al

(2008) identified event characteristics as a key component of disaster impact and resilience. Based on the findings of the study, three main event characteristics can be identified as determining the resilience of a construction SME as outlined below.

#### **4.5.1 Type of EWE**

It was noted by case study respondents that high temperatures and heat wave conditions were more of an inconvenience to site and head office staff, which had minor implications on the business. These have included the need for additional environmental controls and uncomfortable working conditions, but not significant disruptions to work or major financial impacts. However, prolonged disruptions associated with heavy snowfall and low temperatures were identified as exerting severe impacts on construction SMEs. Heavy rainfall was also noted by the respondents as particularly damaging. Therefore, impacts associated with different EWEs seem, to a certain extent, to be different.

#### **4.5.2 Timing of EWEs**

This suggests that the time of year when the EWE strikes and the duration that the EWEs affect business plays a crucial role in determining the extent of the impact on a business. This has also been noted in previous research in relation to other SMEs. For instance, it was recently reported how the heavy snowfall in March 2013 has had a severe impact on farming and livestock SMEs, as the event occurred during the lambing season, which was said to be a key period for farming (BBC News, 2013). On a similar note, the pre and post-Christmas period can be identified as a key time period for construction SMEs, because of the two-week Christmas break and productivity losses before and after the Christmas. Further, summer months where construction SMEs expect to intensify their construction activities also seem critical as weather disruptions in this period can have a significant impact on their project completion and income.

#### **4.5.3 Duration**

The duration of EWE disruptions was identified as a factor that contributes towards resilience of construction SMEs. Not being able to generate income from projects over a lengthy period of time can cause significant financial implications to construction SMEs, even leading to business failure. Whilst identifying that even intermittent EWEs of short duration can be costly; especially during times when extra resources are required on site to accelerate work and recover time lost due to a previous EWE, the relationship between the duration of an EWE and its impact; especially financial impact, was highlighted by the respondents.

### **4.6 External factors**

Business organisations operate in a dynamic environment consisting of social, economic, and political environs. Therefore, these external factors are likely to have an impact on the resilience of construction SMEs. For example, changes in policy governing climate change adaptation or flood adaptation can be cited. The major external factor that emerged as influential in the study was the wider economic climate. It was noted by case study respondents that the tighter economic situation prevailing in the UK at the time has contributed towards EWEs having a significant impact on construction SMEs. As noted by Price et al (2013) and Eadie et al (2013), the recession that prevailed in the UK in 2008 – 2009 had major consequences on the construction industry, and construction SMEs in particular. Therefore, this has adversely affected the resilience of construction SMEs to the EWEs that affected them during the time of recession and the prolonged period of low economic growth that followed. Hence, the wider economic climate can be identified as a major external

factor that affected the resilience of construction SMEs to EWEs. Among others, similar findings were reported by Tierney (2007) and Webb (2000).

## **5 Updated conceptual framework and its importance for policy and practice**

Based on the findings of the study, the initial conceptual framework developed was populated as shown in Figure 3. Accordingly, the key criteria for vulnerability, coping capacity, coping strategies and characteristics of EWEs that contribute towards the level of resilience were included within the conceptual framework. As discussed above, the criteria for vulnerability included the size of the SME, specialisation, diversification and spread of projects, extent of sub-contracting, and location of projects. The key criteria that determine the coping capacity of a construction SME were identified as previous EWE experience, how well established the SME is, financial capacity, availability of expertise, and experience of senior. Coping strategies were sub-categorised based on the risks that they seek to address and whether they are focused on construction projects or at organisational level.

As part of the development of the initial conceptual model, the wider economic climate was included as an overall key factor to reflect its influence on the level of resilience of SMEs following the discussions and analysis of case study findings. Similarly, analysis of the case study findings pointed to certain characteristics of EWEs; type of EWE, and timing and duration, as having a key influence on the resilience of construction SMEs. Accordingly, event characteristics and the wider economic climate which were not part of the initial conceptual framework were included based on the findings of the study. Therefore, the resilience of a construction SME to EWEs can be seen as a collective effect of the vulnerability, coping strategies and coping capacity of the SME and its supply chain, characteristics of the EWE and the wider economic climate.

This novel conceptual framework provides a blueprint for enhancing resilience of construction SMEs. The conceptual framework primarily improves the understanding and awareness of resilience and vulnerability of a particular context among SMEs. Then it allows various SMEs in construction to move forward in building up their resilience against extreme weather events. As pointed out earlier, the construction industry contributes significantly towards the GDP of a country and due to its main constituents being SMEs, economically smaller improvements in resilience at micro level (i.e. concentrating on an individual SME) will achieve significant improvements at industry level due to the multiplier effect. From a theoretical perspective, further research can be undertaken to conduct case studies with a significant number of construction SMEs to both modify and validate the framework based on evidence to emerge. Comparisons can then be made between micro, small and medium sized organisations to observe whether significant differences exist. From a practical perspective, a method to quantify the importance of each factor can be integrated to the framework, to enable construction SMEs to assess their level of resilience. This will enable construction SMEs to use the framework as a tool to assess their level of resilience to EWEs and thereby identify and take action to improve the same.

Investing in disaster risk reduction for resilience is a priority identified in the Sendai Framework adopted following inter-governmental negotiations (UNISDR, 2015). To achieve this, it is recognised that it is important to “increase business resilience and protection of livelihoods and productive assets throughout the supply chains, ensure continuity of services and integrate disaster risk management into business models and practices” (UNISDR, 2015). This statement is highly relevant to a sector like construction, as the resilience of construction sector and its businesses is crucial for enhancing disaster resilience, preparedness and recovery. Further studies have been undertaken on

resilient businesses and resilience investments by the World Bank (see GDFRR (2015) and UN-ESCAP (Edo and Abe, 2014). These new initiatives and studies also have an impact on building resilience in the construction industry. The expanded conceptual framework lays the foundation to further develop knowledge and understanding on resilience of SMEs in the construction sector and make crucial policy and practice interventions to improve their resilience.

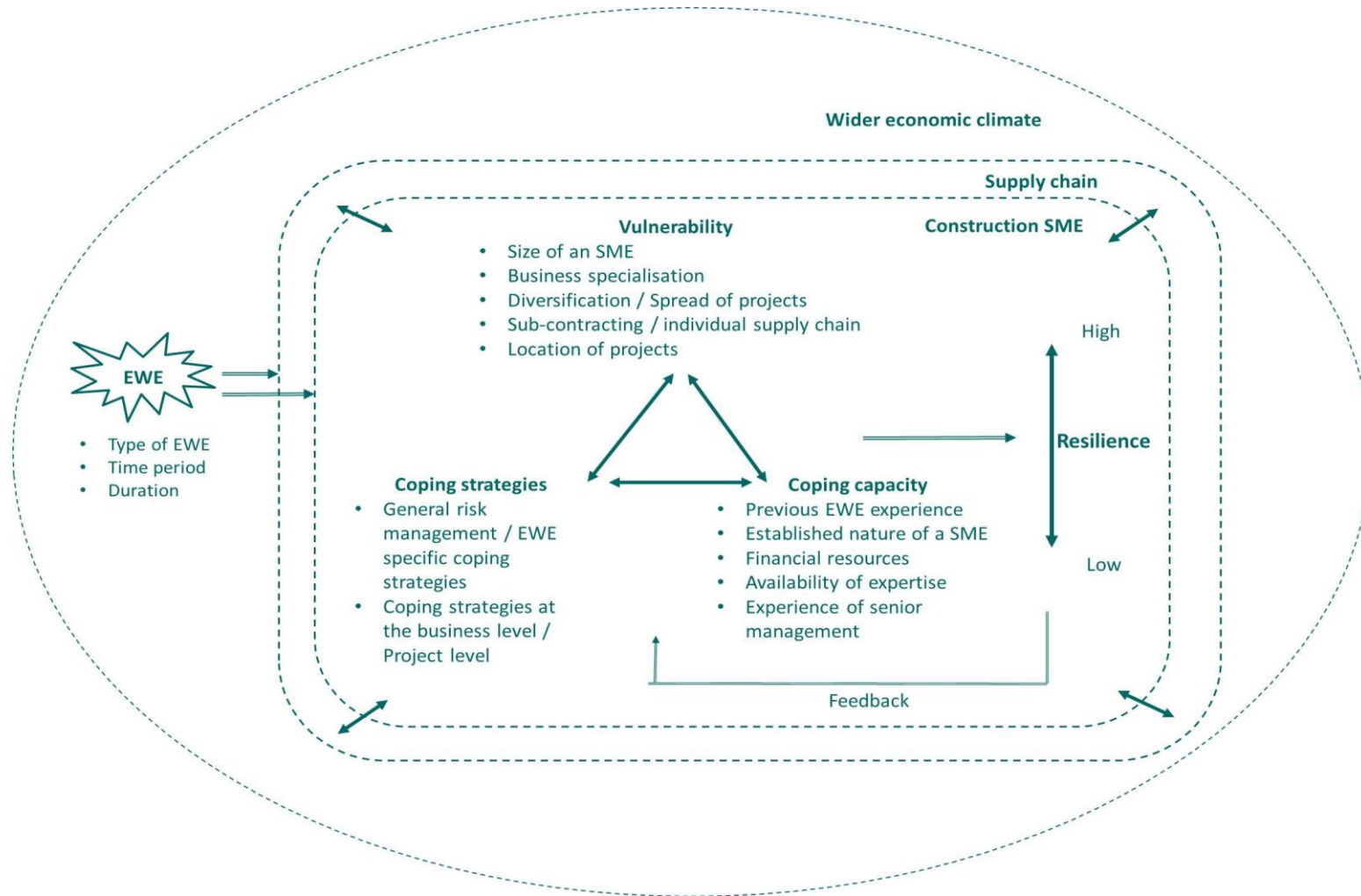


Figure 3 - Expanded framework for EWE resilience on Construction SMEs

## 6 Conclusion

An initial conceptual framework was first developed to represent EWE resilience of SMEs, based on extant literature and the researchers' interpretation of resilience and related concepts. This was validated during the subsequent phases of the research. The initial conceptual framework was then populated and expanded based on the evidence emerged from the case studies of construction SMEs; to represent the EWE resilience of construction SMEs.

Accordingly, the starting point of the framework is the characteristics of an EWE. The characteristics of the EWE will contribute towards the impacts that it has on a construction SME and / or its supply chain. The level of resilience a particular construction SME can achieve against those impacts will depend on its vulnerability, the coping strategies that are in place and its inherent coping capacity. The external factor of the wider economic climate will have a bearing on the level of resilience the SME can achieve. Whilst the framework is based on the conceptual underpinnings of how resilience was perceived at the beginning of the study (resilience as a collective effect of vulnerability, coping strategies and coping capacity within a complex supply chain network), it is grounded within the context of construction SMEs as the expanded framework was informed by the empirical findings that emerged from the study. In this sense, the framework provides a novel way of representing resilience of construction SMEs, as opposed to generic frameworks/models on resilience of businesses / SMEs.

The expanded conceptual framework introduces a novel concept of resilience from a construction SME perspective, which is influenced by existing theories on resilience and related issues but grounded within the context of construction SMEs. The conceptual framework can, therefore, act as a useful tool for policymakers and business support organisations in developing strategies towards enhancing the resilience of construction SMEs to EWEs, as the framework represents key aspects of resilience from a construction SME perspective. The expanded conceptual framework is primarily based on two in-depth case studies of construction SMEs. The focus of the study has been limited to construction SMEs who are contracting companies. As the two case study SMEs were medium sized construction companies, the findings of the case studies can, in the main, be attributed to medium sized construction companies. However, steps such as cross-analysis with the questionnaire survey findings where the majority of the sample was micro sized SMEs (please see Wedawatta et al, 2011), and comparison with the findings of other studies on SMEs, have been followed to increase the applicability of the study's findings to the broader range of construction SMEs. Maintaining homogeneity within the case sample was always challenging given the heterogeneous nature of SMEs. But it has been ensured that the emerging empirical findings and the utility of the framework are clearly resulting from and based on the SME dynamics. Although this might be seen as a potential limitation of the study, that did not affect the core focus of this research where it was able to identify the key issues related to resilience. This provides a conceptual way forward to take this research to the next level.

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