

# Resilience Interpretations of Small and Medium-sized Enterprises and its Analytical Approaches – Literature Review

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**Abstract**—In this study, we review different approaches of resilience in the case of small and medium-sized enterprises (SMEs) that face ever-growing challenges due to the risks arising from the interconnected and globalised environment in which they are embedded. The field of economic resilience is of great interest nowadays due to effects caused by the current Covid-19 pandemic. There are already several thorough concepts elaborated on estimating SME resilience, which have valuable ideas and different aspects incorporated relying on mainly questionnaire survey data. We will list up general features of SMEs that make them vulnerable and possible measures from literature that are highly recommended in order to reduce their exposure to negative consequences to unexpected situations.

**Index Terms**—SME resilience, SME resilience characteristics, resilience engineering, change management, resilience measurement index

## I. INTRODUCTION

The term of resilience is widely used throughout various scientific areas like ecology, process engineering or even social sciences. The term was already used in literature in 1973 in context of ecological resilience, where it corresponded to the answer given by the system<sup>1</sup> to a disturbing effect originated from the environment. Such that, it incorporates the system's flexibility, adaptability and efficacy properties and it can be characterised by the speed with which the system returns to its original, unperturbed state or by the magnitude of the unexpected environmental perturbation the system can still absorb and survive [1]. We can find definitions in the literature about economical resilience –or more directly SME related resilience– already from the year 2000. Nevertheless the huge variety of definitions and the lack of exact mathematical interpretation due to imprecise knowledge of the system and threatening risk factors makes SME resilience an actual research field [2], [3].

Besides the negative impact of the present Covid-19 pandemic on the European economy there is an already present external motivation to treat resilience as a highlighted, state-of-the-art research area. This motivation originates from the USA,

<sup>1</sup>The investigated subject of each scientific field in presence of crisis. In the following it denotes the SME as an organisation or its analysed divisions and business areas.

where Barack Obama US president announced a program in 2010 in order to make 16 strategically important sectors inevitable to the proper functioning of the economy and the nation of the USA more resilient. The goal of this defense-oriented thrive is to create a more resistant country against the challenges of the 21st century and gave momentum to the research of economic resilience [4]. This corresponds with the observation (see Figure 1) that there is a more active work in the scientific literature since 2011 regarding economic resilience of SMEs [5], [6].

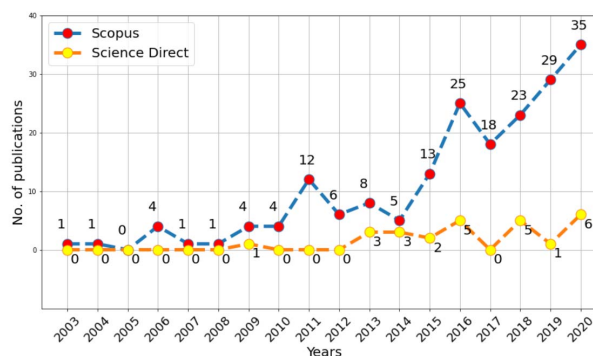


Fig. 1: Number of publications with the search word "SME AND resilience" in title, abstract or key terms in Scopus and Science Direct.

Since SMEs build the backbone of the economy of the EU, which gives approximately 99% of the total enterprises, more than two-third of the total employment can be attributed to them and still can produce net employment increase. Thus it is essential to foster the growth of the SME sector that contributes to the overall competitiveness of the economy [7]. Likewise to have a clear understanding of the state of SME resilience and the factors effecting it is paramount in order to support government decision makers in reallocating resources destined to the sector in case of an economic depression [8].

## II. INTERPRETATION OF SME RESILIENCE IN LITERATURE

Due to different definitions of the SMEs around the globe there is a different scaling of the companies, which makes the

comprehensive definition of SME resilience subtler [9]. Within the EU, the economic definition for SMEs specifies companies having less than 250 employees and less than 50 million EURs for annual turnover [10]. For a more detailed specification see Table I.

SME category	Staff size	Annual turnover	Annual revenue
Medium	< 250	≤ 50 m €	≤ 43 m €
Small	< 50	≤ 10 m €	≤ 10 m €
Micro	< 10	≤ 2 m €	≤ 52 m €

Table I: The definition of the European Union Commission for SME categories, where annual numbers are given in million EURs [11].

Most of the authors in reviewed literature agree that resilience is not a static but rather a time dependent attribute of an enterprise since the resilience is the answer of the system given to a disturbance by withstanding to the negative effects and by quickly returning to stability [12]. Such measure shall be at least monitored on a yearly basis in order to get a picture of its evolution in time and time dependent company data shall be investigated, which incorporates recession periods in the enterprise’s life.

However, the time dependency of the recovery can be quite diverse or even extreme. Some companies may return to a stable position faster than others and this regained stability might be at a different level compared to the pre-disturbance state. Therefore questions arise, how resilience shall be measured based on time dependent "hard data" that might mean any fiscal data (e.g.: annual revenue, net profit etc.) which were monitored throughout the depression period [13]. In case of investigating two different company’s descriptive fiscal data ( $X$ ) (see Figure 2), there can be different levels ( $X_A, X_B$ ) of the same data and having different time windows of the change in the values of  $X$  different relaxation dynamic can be interpreted with different levels of stabilisation compared to the level at  $T_0$ . A proper understanding of this dynamic is desirable, which can give an idea of standardisation of time dependent descriptive data or based on their time behaviour the companies in our focus can be segmented into different groups and investigated further separately.

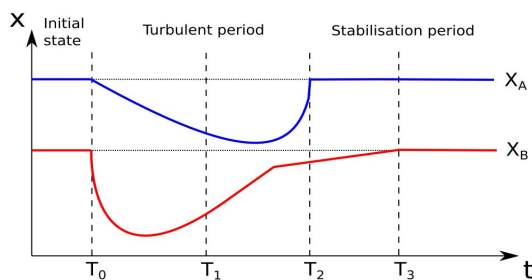


Fig. 2: Different time dependent dynamic of the relaxation of a descriptive "hard data" throughout an economic depression period [13].

The time dynamic of the "bouncing-back" phenomenon may

depend on several factors (e.g.: company size, type of industry, management decisions, preparatory actions etc.) and according to Erol et al. [13] the definition of resilience in general can be phrased as the whole of actions (preventive, defensive and restoring measures) taken before and during the unexpected perturbation. Thus, in this concept the economic resilience of an enterprise originates from this preparatory stage. This corresponds to the end-result of a planning activity rather than just a descriptive feature of the actual, static state of the system.

To the aforementioned interpretation a quite analogous approach is the usage of change management to describe resilience. This involves the actions taken as a response to an event – let it be planned or unexpected – and their efficacy as an important adaptation capability. It also characterises the level of preparedness within the organisation and how fast it can reallocate its technical and organisational capacities in order to withstand the changes. This sheds light on the interesting property of the resilience through the general experience of change management – despite being led either by prescribed best practices or standardised procedures – that it is a typical iterative process of trial-and-error phases with its unavoidable pitfalls. Therefore in this aspect, resilience is rather a result of a development- or learning process than just a characteristic of a system [14].

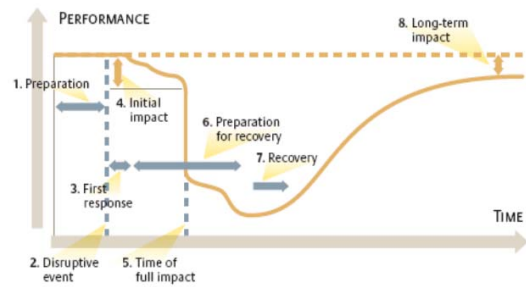


Fig. 3: Phases of a disruptive event viewed in the changes of "hard performance data" as a function of time [13].

Erol et al. [1] divides the stages of disturbing phenomenon into eight sections throughout which the companies resistance capability shall be monitored (see Figure 3). These eight sections already begin with (1) the preparation to the event before (2) the disturbance would occur. Thereafter the first impacts in the company’s operation can be observed and (3) initial measures are taken to soften the negative influences and try to compensate back to the original state. Afterwards, in a presence of more severe circumstances further (4) initial negative effects are observable and later the (5) full impact unfolds itself. In the next stage the company begins to take measures to the (6) restoration of the original state and (7) put the measures of restoration fully into effect. In the last step the (8) long term results end effects are to be observed that already belong to the new stable state at the same or different level compared to the state prior to the disruptive event.

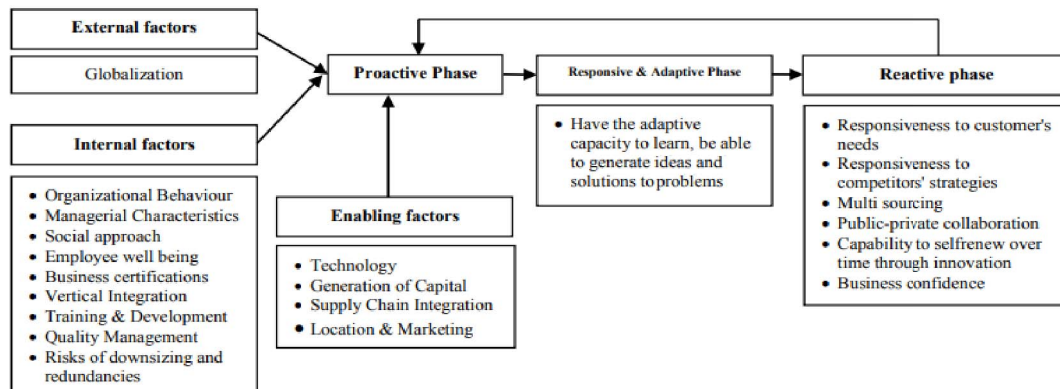


Fig. 4: The conceptual framework of resilience investigated by Supardi et al. with proactive, adaptive and reactive phases [5].

According to Supardi et al. [5] there are three different approaches of resilience corresponding to the time dependent dynamic of the "bouncing back" phenomenon. In case of perturbation and in business terms resilience shall be interpreted as crisis management. These crisis management approaches are the proactive, the adaptive and reactive resilience (see Figure 4).

Under proactive resilience the SME's preparedness shall be understood, their special business setting and crisis managerial mindset which can be applied under an unexpected situation. This implies business continuity and is bonded to the skill of forecasting and reacting on impacts that might harmfully influence the business processes.

The adaptive resilience is interpreted as a surviving capability under changed circumstances, how tough the business processes of the SME's are (e.g.: can they maintain their business connections during the depression phase). It also covers a learning willingness and the ability to implement the lessons learned in order to boost development and preparedness. This means a competitive and sustainable adaptation of new knowledge in a turbulent working environment and the capacity to react on changes that –in case of survival– generates motivation and innovation.

The reactive approach of resilience deals with the output side of the change management process and it is interpreted as the ability of the company to recover after the crisis and consider this period as a learning possibility that helps it to renew and restructure. Therefore reactive resilience represents the SME's ability to come out of the turbulent phase stronger, can restore or even maintain their business processes by limiting and absorbing the negative effects and they can still manage to carry out their business priorities.

Vries et al. [9] pointed out, that the resilience of SMEs is also highly dependent on the owners leading attitude and entrepreneurial skills which means a further challenge to the analytical investigation of resilience. The authors inspect resilience from the entrepreneurs viewpoint and defines it as a stress-resistance capacity of the entrepreneur and connects its formation to learning habits, presence of continuous

trainings, family background, geographical position and local entrepreneurial mindset and traditions. They see the long-term survival of the company in the ability to learn from successful SMEs that is often up to the owner's attitude. They define four main personal characteristics that is essential to the company's resilience. These are the (1) flexibility, which covers the easy adaptation to changed circumstances and the ability to seeking solutions to it, the (2) motivation, which is essential for seeking new goals that implies an aspiration to have an impact on the environment, the (3) perseverance that is in connection with the time and energy that is invested into the company and finally the (4) optimism that is indispensable for treating problems as challenges, opportunity for development and for the willingness to take risks.

Until now companies were viewed as a standalone systems that have special properties that may contribute to their resilience. However, in real life SMEs are in an interconnected structure and they are typically forming a part of a supply chain. They tend to outsource activities like bookkeeping, consultations, IT maintenance, tax matters, benchmarks or trainings, which next to the presence of a multi-layered supplier network supports the idea of extending the resilience investigations to a broader environment [13], [15].

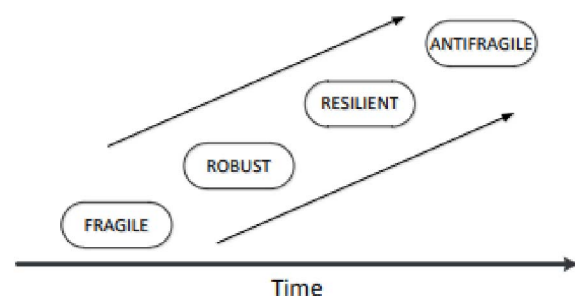


Fig. 5: Stages of four-level resilience maturity model [16].

Ruiz-Martin et al. [16] interpreted resilience as an intermediary step in a four-leveled resilience maturity model. In

their view, depending on the development and abilities of the organisation, the SME can be treated as a fragile, robust, resilient or antifragile system (see Figure 6. The fragile system collapses right away a disruption occurs. The robust system can tolerate the stresses until a certain extent, then collapses. The resilient system not just tolerates but also survives the turbulent period with manageable losses, while the antifragile system not just survives the turbulent period but also makes advantage out of it (e.g.: by innovations, new contacts, loss of competitors etc.). Therefore, in this context the development goal of the resilient feature of SMEs is clearly selected and attention to a new research area of the "antifragility of SMEs" is also drawn.

### III. RESILIENCE METRICS IN THE LITERATURE

As described in Section II there are various interpretations of the SMEs' resilience. Different authors highlight highly dissimilar properties that might have an influence on this company property and so far there is no consensus on a mathematical definition that would cover all these aspects. In this section we will present some of the concepts shown in literature that propose a mathematical procedure for SME resilience estimation.

Afgan et al. [17] proposed a method based on using "hard data". They defined the resilience index as a weighted sum of the time integrals of indicator values that are monitored throughout the period of perturbation (see Figure 6). As indicator values he considered the company profit, company income, final product price and company manpower:

$$R = \sum_{i=0}^n w_i \int_{t=T_0}^{t=T_1} [1 - q_i(t)] dt, \quad (1)$$

where  $q_i$  is the  $i$ -th monitored indicator and  $w_i$  is an appropriate weighting factor.

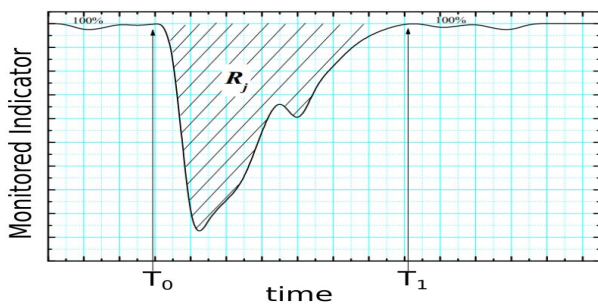


Fig. 6: Sudden change in the "j"th monitored indicator throughout a turbulent period. The corresponding resilience metric is depicted from the hatched area [17].

As a similar concept Coates et al. [18] calculated operational resilience from the deviations of production capacity as a monitored indicator factor. The production capacity loss ( $PC_{loss}$ ) was given by the area above curve integral over time. Then this loss was expressed as a the percentage of the total production capacity ( $PC_{normal}$ ) –that would have

been without disruption– of the investigated time interval. Afterwards the resilience index was calculated as:

$$R = 1 - \frac{PC_{loss}}{PC_{normal}}. \quad (2)$$

The authors verified their model on simulated data, no real-life verification were presented, however they highlighted that such methods cannot be applied in the lack of a turbulent period and continuously monitored indicators.

Aleksić et al. [2] investigated "soft data" collected from senior managers via questionnaires and oral discussions. The importance and vulnerability of certain key areas were described by linguistic expressions on a Likert scale. They aggregated the individual answers of the respondents –that had unequal importance in the group consensus– with a fuzzy ordered weighted averaging operator (FOWA). The importance of the respondent's answers were set based on their position in the company and compared to reference best practice values from given industries. By setting up a fuzzy decision matrix, the method could serve with simple values for resilience in range of [0..1] for business processes and for the organisation itself.

Jung et al. [19] presented a Cox regression survival analysis based on panel data. Their focus was to verify whether R&D invests and innovative activities have a positive effect on long-term survival. They used time-varying "hard data" and dummy variables depicted from statistical information to presume the presence of innovation or patents etc. (e.g.:they assumed R&D activities in the presence of government or international funds). Based on their model they could investigate correlations between input factors and survival of companies that had been monitored through 5 years in case of 588 South Korean SMEs.

Sausser et al. [8] showed an agent based modeling approach to study the breakdown of a complete system of companies and thereby the resilience of communities and regions. In their simulation SMEs were placed on a grid as abstract points and were equipped with properties like resilience (whether they are able to reopen once), type of their customers (local or global markets) and belonging threshold (how much they depend on the state –open or closed– of the surrounding grid points). However the model was initialised by random numbers it showed that increasing the severity of the disturbance, after a tipping point the whole system collapses due to the cascade-like failure of the interacting SMEs. Such a model with real-life regional input data can serve with valuable information on regional interconnectedness of SMEs' and overall resilience of communities.

Graça et al. [12] suggested the investigation of a collaborative business ecosystem with graph theoretical approaches. In such a model the size of largest connected graph components<sup>2</sup>, average- and maximum path lengths<sup>3</sup> within the largest connected components were considered as resilience metrics. In order to take the different importance- and role of

<sup>2</sup>A subgraph where there is a pairwise connection between all nodes.

<sup>3</sup>Largest path length between any two nodes.

the nodes into consideration "supply"- and "demand" nodes were defined. Size of subgraphs with at least one supplier node, average- and maximum path lengths between supply and demand nodes were proposed as resilience characterising metrics.

According to Somers [20] there is only sense to interpret the level of resilience after a disturbance occurred (if the company survived it). In his work a latent resilience –that is not presently evident or realised– was estimated based on questionnaire data that provided ordinal-type data on a five point Likert-scale regarding factors that were assumed to influence resilience (e.g.: goal-oriented solution seeking, critical situation understanding etc.). Afterwards Pearson's product-moment correlation coefficients, one-way ANOVA and multiple regression methods were used to estimate influences of organisational behaviour on resilience.

#### IV. SME BEHAVIOUR IN CASE OF UNEXPECTED DISTURBANCE

The turbulent environment caused by the continuously changing globalised market results different kinds of challenging situations in an SME's life. These challenges can be caused by economic recessions, crises (like the Covid-19 pandemic) or among others by competitive changes in the SME's market like the emergence of new competitors, new substituent products or the changing bargaining positions of suppliers and customers [7].

The challenges that SMEs have to face can be either sudden that might cause big disruption at certain areas or even slow and insidious, which is hard to recognise in the beginning but can still disrupt key areas and with time can cause cascading troubles. For this reason, it is important to have a comprehensive picture on the linkages among different operation areas and map their vulnerabilities, their exposure to failure in the presence of perturbation, the potentially arising problems and their magnitudes in case of a total failure [17].

The last global economic crisis took place in 2008-2009 and it has had imbalanced impacts on companies depending on their size. The smaller SMEs suffered more, they were affected more by market shrinkage and the bank loans were higher for them because of the elevated risk compared to bigger companies. Therefore they had to make more employees redundant [19].

Bhamra et al. [21] presented results from studies showing that nearly half of the SMEs in the UK had absolutely no strategy in case of a business discontinuity. While Chen et al. [22] concludes, that unfortunately SMEs do not possess enough resources and personnel to review and map their improving possibilities, their operations are not transparent enough. For this reason they are unable to get a proper view of their own status of resilience.

Moreover, next to daily operation in a company with limited financial- and labour resources and insufficient strategical thinking, the management is deprived of the possibility of investigating the company's resilience. In order to make the management interested in investing into improving resilience

simple and clearly understandable indicators shall be examined, otherwise there will be always some other activity that enjoys more priority [23].

#### V. APPROACHES TO IMPROVE SME RESILIENCE

From the resilience point of view SMEs shall be treated together with their ambient partner-system (business environment) that is also increasingly exposed to the changing constraints due to globalisation. A greater emphasis shall be put on the training of human workforce and forming its resilient mindset, because the organisation can become resilient only by the proper business processes and the adequate contribution of the personnel [2]. Similarly Patriarca et al. [24] suggested SME resilience to be depicted not from the characteristics of the company but rather than from the activities it does.

SMEs are typically centralised organisations that only rarely practice business management processes or does not have a managerial layer at all. They are more influenced by human factors of the decisionmakers' side compared to the larger companies. Since the majority of SMEs are family businesses, mainly the owners shall be incorporated into resilience enhancing activities like cooperation with local governments, universities and chambers of commerce. Thereby more favourable local strategies are to be expected that can respond more adequately to the arising global challenges. [15]

These companies are great knowledge generators but they are poor in knowledge accumulation. With adequate knowledge sharing and flexible treatment of workforce they would be able to give more value to the company, explore customer needs more and retain them [15].

This knowledge sharing can be utilized among several companies in a form of cluster cooperation. Such a goal oriented and focused business scheme fosters focused business orientation by an interoperable collaborative structure and promotes mutual confidence building. Taking part in such a strategic structure enables the partners to realise mutual advantages that would be otherwise impossible. By the presence of modern ICT<sup>4</sup>-tools (e.g.: having internet, smart phones, usage of online applications) close connections are easier to maintain and can cover various departments. By working in a cluster scheme the companies can share their knowledge, which can decrease uncertainty and business risks. They can enter new markets with lower invests, increase their negotiation potential, develop new products or compete even with larger firms [12].

Cooperating in clusters can also contribute to communication with the actors of the supplier chain. This is especially essential with an increasing company size, which due to the decrease in transparency implies further negative impacts on the overall resilient behaviour of the company [5].

According to size and industry, an appropriate organisational structure shall be applied with modern operative strategies and tools as well as the reduction of organisational complexity is preferable for long-term survival [13]. Additionally, a powerful quality management, quality assurance

<sup>4</sup>Information and Communications Technology

and continuous internal development system would be advisable as it is the case at most of the bigger companies and multinationals. The SMEs should have a proactive attitude to technological novelties (e.g. social media tools) and be open to further development possibilities, like management trainings in regular time periods to enhance resilience [15].

Nevertheless, the proper choice and implementation of new technologies is needed. Although, according to Jung et al. [19] innovation and R&D investments do not help in general to get by with turbulences. Putting emphasis on innovation with improper capacities or insufficient results is definitely more harmful for SMEs than omitting such activities. As an example, Hansen et al. [11] mentions the usage of AI<sup>5</sup> technologies. These would already be useful to utilize at present to a certain extent. However, due to the complexity of the methods at current stage makes them overly risky and unnecessary for allocating too much resources to their usage. The SMEs shall take advantages of already elaborated and easier to use tools, which can help them to decrease their exposure to outer threats (e.g.: cyber attacks) and thereby improve their overall resilience.

## VI. CONCLUSIONS AND FUTURE WORK

In this paper, we reviewed various approaches of SME resilience which is of high interest lately due to the economic aftermath of the Covid-19 pandemic. Some of the most promising analytical concepts for resilience estimation have been listed up like using Cox-regression, Fuzzy approach or agent based modeling. The usage of these models present a good association of methods used in different scientific fields and SME resilience. The data that were used for model estimation basically relied on questionnaires and interviews, which can grasp the SME specific characteristics with regard to their size, industry and other aspects. SME related specific features have been listed up together with recommendations in order to enhance resilience

In a future work we intend to investigate Hungarian SMEs from the aspect of resilience based on statistical "hard data" and questionnaire results. For this purpose a simply-interpretable resilience measurement index shall be derived that can be used to identify vulnerable areas and serve as a comparative indicator within an industrial sector. With a special interest we would like to investigate "high-growth" SMEs and the effects of the introduction of ICT technologies onto the overall resilience.

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<sup>5</sup>Artificial Intelligence