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RESEARCH PAPER

A Systematic Literature Review of Organization Resilience, Business Continuity, and Risk: Towards Process Resilience and Continuity

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Abstract
This study attempted to review the articles and explore the gaps and challenges in the areas of resilience, business continuity, risk, and process safety with the aim of providing several directions for future research to understand different research directions in these areas with different perspectives. In addition, in this study, the relationship of articles in these areas with each other was examined. In this research project, related studies were reviewed and reported to identify presented frameworks, models, and methods for them. In the first phase, the articles were divided into three categories according to their similarity, namely “maximizing the value of business continuity and resilience,” “maximizing process safety and the effect of risk and resilience factors,” and “minimizing risk and effect of uncertainty.” In the second phase, the appropriate conceptual frameworks titled “research house” based on resilience, business continuity, and risk categories were created for each category. In the third phase, 22 closed codes were obtained by carefully reviewing the articles, and their co-occurrence network was investigated. The main findings of this article were categorizing the studied articles, providing conceptual frameworks resulting from article analysis, and presenting a conceptual model.

Keywords: resilience, business continuity, risk, process safety, resources.

1. Introduction

Process optimization is of particular importance because it leads to the achievement of organizational objectives and facilitates the execution of organizational missions in an efficient and effective manner. Process optimization in organizations refers to increasing organizational efficiency through process improvement. Organizational efficiency is related to the optimal resource allocation, so efficient organizations not only do not waste resources but also allocate resources properly. However, in case of incorrect allocation of resources, it causes a lot of damage to organizations. Organizations are always trying to make the best use of available resources in times of crisis. Due to the increasing risks, which in some cases lead to major disasters, the community needs a business continuity program to prevent the cessation of activities in the community by identifying the existing crises. In addition, due to the thousands of accidents that occur in the world, a large number of people die. These events

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impose a great financial burden on society. Therefore, it is necessary to predict and control these events. One of the best ways to prevent these accidents is to use risk management. In such a situation, society always tries to be prepared for disasters by using different approaches in the fields of business continuity management – such as risk management, crisis management – or creating a state of resilience. In fact, when a destructive event occurs, resilience manages it, which can ultimately reduce the duration of the disruption or decrease its impact on system performance (Taleb-Berrouane & Khan, 2019). In addition, when a destructive event occurs, the business continuity causes the production or service activities not to stop and continue to operate (Zio, 2018). Resilience is a process that allows individuals to adapt to adverse conditions and recover from them (Dantzer et al., 2018). Business continuity is defined as "the ability of an organization to continue delivering products or services at acceptable levels after a destructive event" (Zio, 2018, pp.13).

The objective of business continuity management is to ensure that no adverse events lead to unexpected and unwanted interruptions in production or service activities (Zio, 2018). One of the most important aspects of the BCM field is the discussion on product recovery after a destructive event and the resource allocation for this purpose (Ostadi et al., 2021). Defining risk, Marhavilas and Koulouriotis (2008, pp.596) assert that "it is possible that someone or something being evaluated will be severely affected." Aven (2016, pp.8) defines risk as "deviation from a reference value and associated uncertainty." Process safety includes hazard identification and analysis, risk analysis and mitigation, incident modeling, consequence analysis, and many other actions (Amin et al., 2019). Despite many years of initial research on resilience, business continuity, risk, and process safety, these concepts still lack a comprehensive and operational understanding in various scientific areas, including crisis management. Natural disasters, which are part of the process of human life and whose number and diversity are increasing every day, have been considered as a fundamental challenge to achieve resilience and continuity. As a result, recognizing the methods of resilience and continuity has been included in crisis planning and management by various models of vulnerability reduction. Therefore, considering the disruption and various incidents that exist in societies, organizations, and companies, it is very important to pay attention to the concepts of resilience, continuity, risk, and process safety. Therefore, in this article, we have tried to introduce these concepts and analyze them and provide several directions for future research in the mentioned fields to improve societies and organizations in crisis. Given that incidents that occur in society are uncontrollable, the question is that if it is not possible to completely prevent accidents, what can be done to minimize the damage caused by it. How can communities or organizations be prevented from stopping their activities? How can the losses and damages be reduced in conditions of disruption and crisis? Therefore, issues such as resilience, business continuity, risk, and process safety can be relevant. In this paper, the considered studies were reviewed from two perspectives. First, articles in the mentioned fields were scrutinized for their key sentences. Then, the articles were analyzed based on their similarity, they were classified, and conceptual frameworks were presented based on the classifications made.

The rest of the paper is structured as follows. Section 2 reviews the studied articles. Section 3 describes the method used to review the literature. Section 4 deals with the classification of the articles and the presentation of a conceptual framework. Finally, Section 5 describes the gaps and conclusions, and provides a framework for future research.

2. Literature Review

In this section, a review of the literature in the areas of resilience, business continuity, risk, and process safety is provided. To present a broad coverage of literature review of resilience, business continuity, risk, and process safety, the selected articles were analyzed in five steps. These included review of different articles, categorization of different articles according to their similarity, presentation of appropriate conceptual frameworks for each category, presentation of 22 closed codes through careful review of articles and their co-occurrence review, and presentation of their co-occurrence network. The problems of resilience, business continuity, risk, and process safety were presented together because organizations face lack of resource when allocating resources in critical situations and this might lead to their disruption and ineffectiveness. Therefore, the subjects of resilience and business continuity needed be considered by considering the risk when allocating resources so that resources are allocated optimally in times of crisis and organizations are not disrupted when faced with a lack of resources.

Conducting research in the areas of resilience, business continuity, risk, and process safety is a new problem that is very important for organizations to address. In fact, due to the increase of crises in organizations, paying attention to the structure and conceptual frameworks of these areas is very important. As we know, resources are a fundamental component of various organizations, departments, and centers, and without resources not only do they have no meaning, but their management will not be possible. Optimal resource allocation helps organizations to ensure the status of their resources, know surplus resources, and be aware of the lack of resources in different sections. In general, the problem of resource allocation is considered due to limitations in the use of resources. The problem of resource allocation can be considered alongside the criteria of resilience, business continuity, and risk. In fact, due to the increasing risks, which in some cases lead to a major disaster, the community needs a business continuity program to identify existing crises to prevent the discontinuation of activities and resources allocation due to their lack in times of crisis. In such conditions, the society is always trying to be prepared for disasters using different approaches in the areas of business continuity management, such as risk management and crisis management or creating a state of resilience.

The articles reviewed in this study cover various areas of knowledge in the areas of risk, resilience, or business continuity. These areas can regard different fields of resource allocation, organizational processes, or organizational issues. In this section, through CiteSpace software, four high-reference articles in the area of business continuity and resilience were obtained. For example, in the area of business continuity, the Herbane's article (2010) has been referenced for 6 years from 2012 to 2018. The article by Sahebjamnia et al. (2015) has been referenced for 5 years from 2015 to 2020. In the area of organizational resilience, Kantur & İşeri-Say's article (2012) has been referenced for 3 years.

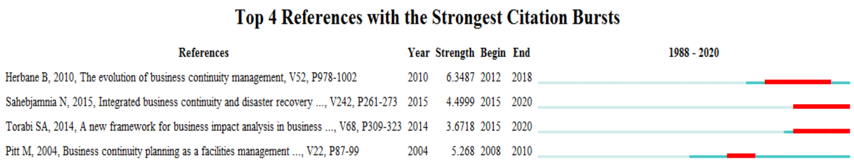

Figure 1. Top Four References With the Strongest Citation (Business Continuity Domain: 1988 to 2020)

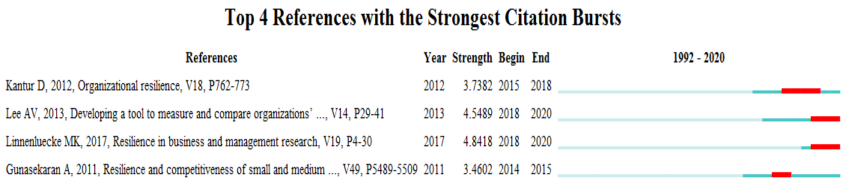

Figure 2. Top Four References With the Strongest Citation (Organizational Resiliency Domain: 1992 to 2020)

2.1. Resilience

In the literature, there have been proposed various models, methods, and frameworks to analyze and measure resilience. These regard various fields of application such as ecological systems, economics and financial systems, seismic engineering and structural systems, service systems, and telecommunication systems. According to the literature review in the field of resilience, various mathematical methods have been used to measure resilience, including neural network (Paltrinieri et al., 2019), conceptual frameworks (Gibb & Buchanan, 2006, Madni & Jackson, 2009, Omer et al., 2013), optimization model (Almoghathawi & Barker, 2019, Najarian & Lim, 2020)، simulation models (Mokhtarian Daloie et al., 2019, Yarveisy et al., 2020), fuzzy logic model (Ostadi et al., 2018), structural Equation modeling (Azusa & Hiroyuki, 2013), and fuzzy cognitive map (Azadeh, A., Salehi, V., Arvan, M. et al., 2014). In 1973, Holling (1973, as cited in Bhamra, 2011) conducted the first research on the concept of resilience in a study called “Resilience and Stability of Ecological Systems.” Holling’s research has formed the foundation of subsequent studies on the concept of resilience (Bhamra et al., 2011).

Bruneau et al. (2003) have also proposed a deterministic static metric for measuring the rate at which a community loses its resilience against an earthquake. It is calculated by Equation 1 where Q(t) is the quality of the community infrastructure in the time interval t_0 to t_1. Performance is also considered to be between 0% to 100%, where 100% means no degradation of services and 0% means non-provision of services.

$$RL = \int_{t_0}^{t_1} [100 - Q(t)]dt \quad (1)$$

Chang and Shinozuka (2004) propose a probabilistic approach to assess resilience in which resilience is measured by the two elements of performance loss and recovery length. In this model, resilience is defined as the probability that a system will meet the predefined performance standard A in a seismic scenario such as *i* or Pr = (*A* | *i*).

$$\Pr(A|i) = \Pr(r_0 < r^* \text{ and } t_1 < t^*) \quad (2)$$

Rose (2007, as cited in Cox et al, 2011) defines the concept of economic resilience with two indicators, namely static resilience and dynamic resilience (Cox et al, 2011). DSER (Direct Static Economic Resilience) in Equation 3 is defined as a static model where ΔDY% is the estimated percent change in direct output and ΔDY^{MAX} % is the maximum percent change in direct output.

$$DSER = \frac{\%\Delta DY^m - \%\Delta DY}{\%\Delta DY^m} \quad (3)$$

Madni and Jackson (2009) define resilience from different viewpoints and then provide a conceptual framework for resilience engineering.

Enjalbert et al. (2011) propose two metrics for assessing local and global resilience for public transportation systems.

$$\text{Local resilience} = \frac{dS(t)}{dt} \quad (4)$$

$$\text{global resilience} = \int_{t_b}^{t_e} \text{local resilience} = \int_{t_b}^{t_e} \frac{dS(t)}{dt} \quad (5)$$

Zobel (2011) provides an evaluation metric for resilience that is obtained using Equation 7. The single-event resilience function (Equation 7) and multi-event function (Equation 8) are as follows:

$$R(X,T) = \frac{T^* - \frac{XT}{2}}{T^*} = 1 - \frac{XT}{2T^*} \quad X \in [0,1], T \in [0,T^*]. \quad (6)$$

$$R = 1 - \sum_{i} (X_i + X_i')T_i / 2T^* \tag{7}$$

We also use partial resilience when dealing with different scenarios. In partial resilience, we have (Zobel & Khansa, 2014):

$$R_i = 1 - (X_i + X_i')T_i / 2T^* \tag{8}$$

$$R = 1 - \sum_{i} (1 - R_i) \tag{9}$$

where R_i is the partial resilience associated with event *i*, and R is the total multi-event resilience.

Ouyang et al. (2012) created a time dependent metric to measure annual resilience (AR) for multi-risk events, as shown in Equation 10.

$$AR = E\left[\frac{\int_0^T P(t)dt}{\int_0^T TP(t)dt}\right] = E\left[\frac{\int_0^T TP(t)dt - \sum_{n=1}^{N(T)} AIA_n(t_n)}{\int_0^T TP(t)dt}\right] \tag{10}$$

Orwin and Wardle have developed a new metric for measuring resilience by linking resilience with maximum and instantaneous disturbance, as shown in Equation 11. (Ouedraogo et al., 2013):

$$\text{Resilience} = \left(\frac{2 \times |E_{max}|}{|E_{max}| + |E_j|}\right) - 1 \tag{11}$$

Azadeh, A., Salehi, V., Ashjari, B. *et al*. (2014) introduced a new concept of RE called integration of RE or IRE. In addition to self-organization, teamwork, redundancy, and fault-tolerant, it includes top-level commitment, reporting culture, learning, awareness, preparedness, and flexibility (Azadeh et al., 2014). Furthermore, Azadeh, A., Salehi, V., Arvan, M. *et al*. (2014) examined the factors affecting the resilience level of a petrochemical plant and its ability to expand to other industries. The results of their study showed that preparedness, awareness and flexibility are the most important factors among the nine RE factors, and the redundancy is a factor that has the least effect on RE (Azadeh et al., 2014).

Sahebjamnia *et al*. (2015) introduced a new IBCDRP (Integrated Business Continuity and Disaster Recovery Planning) framework. Then, they considered an optimization model while noting the features of organizational resilience to find efficient resource allocation patterns among candidate business continuity and disaster recovery plans.

As can be seen in Equation 12 and Equation 13, the aim of the proposed model is to minimize the total weight of the loss of resilience of key products over time and to minimize the recovery time of total key products (Sahebjamnia *et al*., 2015).

$$Min\ f_1 = \sum_{s=1}^{S} \sum_{t=1}^{T} \omega_s .(L - \varpi_s^t) \tag{12}$$

$$Min\ f_2 = \sum_{s=1}^{S} \omega_s \vartheta_s \tag{13}$$

Bhavathrathan and Pati (2015) provided a criterion for evaluating resilience using the government's crisis network cost, which is the difference between the best operating cost and the operating cost of crisis.

$$\text{STT}^* = \sum_{ij} x_{ij} c_{ij} (x_{ij}, y_{ij}) \tag{14}$$

$$C_{ij}\left(x_{ij}, y_{ij}\right) = T_{ij} + \beta\left(\frac{x_{ij}}{\left(\frac{k_{ij}}{y_{ij}}\right)}\right)^{\alpha} \tag{15}$$

$$\rho = (\text{STT}^* - SO - STT) / \text{STT}^* \tag{16}$$

Dixit et al. (2016) use Chen and Miller-Hooks (2012) paper as the basic paper to evaluate the network resilience index. The result is shown in Equation 23.

$$NRI = \left(1 - E\left(\frac{\sum_{k\epsilon K} \tilde{d}_k}{\sum_{k\epsilon K} D_k}\right)\right) \tag{17}$$

In this paper, an optimization model is presented where the first objective function minimizes the expected percentage of unfulfilled demand, which in turn maximizes the NRI (Network Resilience index), and the second objective function minimizes the total transportation cost due to the movement of cargo on the whole branches of paths after performing recovery activities.

$$Z_1 = \quad \text{Minimize } E\left(\left(\sum_{k\epsilon K} \tilde{d}_k / \sum_{k\epsilon K} D_k\right) * 100\right) \tag{18}$$

$$Z_2 = \quad \text{Minimize } \sum_{p\epsilon P_k} \sum_{a\epsilon A} \sum_{r\epsilon R} u_a\, n_p(\check{\xi})(\tau_a(\xi) + (t_{ar}(\xi) - \tau_a(\xi)\beta_{ar})) \tag{19}$$

Franchin and Cavalieri (2015, as cited in Hosseini, 2016) provide a probabilistic metric for assessing infrastructure resilience of earthquake.

$$R = \frac{1}{P_D E_0} \int_0^{P_D} E(P_r) dP_r \tag{20}$$

Francis and Bekera (2014, as cited in Hosseini, 2016) provide a dynamic resilience metric, as shown in Equation 21.

$$\rho_i = S_p \frac{F_r}{F_o} \frac{F_d}{F_o} \tag{21}$$

Cimellaro *et al*. (2010, as cited in Hosseini, 2016) evaluated resilience in terms of service quality, as shown in Equation 22.

$$R = \alpha \int_{T_{LC}} \frac{Q_1(t)}{T_{LC}} dt + (1-\alpha) \int_{T_{LC}} \frac{Q_2(t)}{T_{LC}} dt \tag{22}$$

Sterbenz *et al*. (2011, as cited in Hosseini, 2016) provided a framework for resilience and survivability of communication networks. They concluded that six factors played a role in the design of resilient networks, namely defense, detect, diagnose, remediate, refine, and recovery. Shirali et al. (2012, as cited in Hosseini, 2016) used a semi-quantitative method to evaluate resilience engineering, in which they introduced six resilience indicators, including top management, learning culture, awareness, commitment, preparedness, and flexibility. Adjetey-Bahun *et al*. (2014, as cited in Hosseini, 2016) provided a time-dependent simulation model to measure the resilience of railway transport system. Azadeh *et al*. (2017) examined the interactions of resilience engineering (RE) and managerial and organizational factors in a gas refinery. The results of this paper showed that learning and flexibility among all RE factors have the greatest impact on managerial and organizational factors.

Gong and You (2018) provided a framework for optimizing resilience, including maximizing resilience in the worst case of accessibility of process units and minimizing total capital cost. Sahebjamnia *et al*. (2018) presented a model for organizational resilience that could respond to several destructive events. In this model, by creating exchanges between the required resources for continuity plans, recovery time, and recovery point, internal and external resources are planned with the minimal resumption time, restoration time, and loss in the operating level of metrics functions.

Xu et al. proposed an optimization model to restore electricity after an earthquake with the aim of minimizing the average time that each customer does not have electricity (Zio, 2018). Jain et al. (2019) proposed an optimization model with the aim of minimizing the total annualized cost and maximizing the expected revenue, as well as evaluating a model for the survival of a process system using the Process Resilience Analysis Framework.

Azadegan et al. (2019) maintained that studying near-miss events – occasions when a company comes close to being negatively impacted – can help identify systemic issues and thereby enhance organizational resilience. This study answered the question that whether exposure to near-miss events can help companies refine their response strategies in facing supply chain disruptions. This study relied on sampling frame and non-response bias, and it was conducted at the organizational level. Results suggested that exposure to near-miss events is associated with a rise in procedural response strategies. In addition, exposure to near-miss events was found to lead to more procedural and systematized approaches to how disasters are handled. In other words, at the organizational level, exposure to near-miss events may limit the propensity to choose riskier propositions.

Najarian and Lim (2020) proposed an optimization model to optimize the resilience of infrastructure to a set of adverse events with the optimal allocation of budget for infrastructure components. In fact, this paper introduced a quantitative approach to increase system resilience under budgetary constraints. Yarveisy *et al*. (2020) defined resilience and measured it by a new perspective. This paper also presented a new set of metrics based on the concept of reliability and maintainability combined with the system modeling approach. Pishnamazzadeh *et al*. (2020) provided a model for assessing hospital resilience based on simultaneous key performance metrics. In fact, they modeled performance from a resilience engineering perspective to improve hospital performance.

2.2. Business Continuity

According to the literature review in the field of business continuity, various mathematical methods have been used to measure business continuity, including optimization model, conceptual framework, event tree model, and fault tree model. The term business continuity was first used in the 1970s to describe accident recovery programs. In the last decade, BCM has attracted the attention of many organizations (Zeng & Zio, 2017).
Kawamura and Nakatani (2010) showed how business continuity management affects and the difference between running and not running it, as shown below:

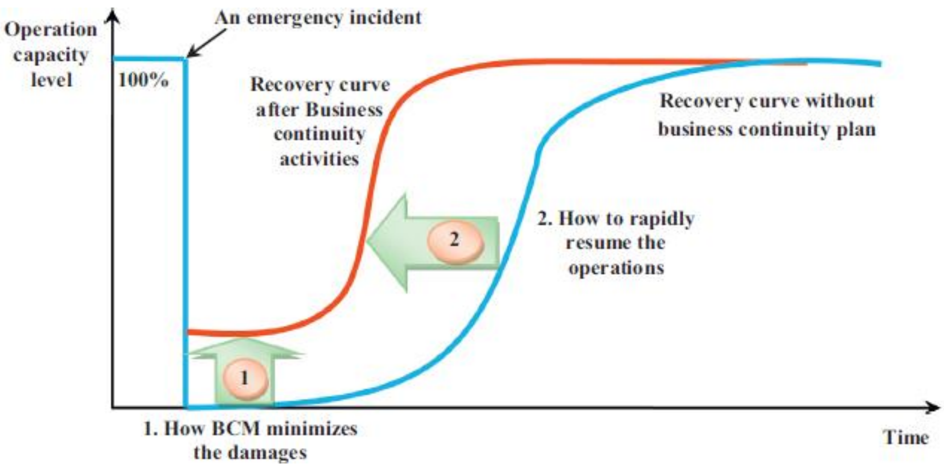

Figure 3. The Difference Between Running BCM and Not Running It (Kawamura & Nakatani, 2010. pp.1407)

In fact, the management of business continuity in the event of a disaster helps the business thrive in two ways: “preventing damage” and “resuming the metrics activities of the business immediately” (Kawamura & Nakatani, 2010, pp.1407).

Stephenson (2010) discussed how measuring the organization resilience over time can help evaluate the effectiveness of Business Continuity Management (BCM) programs.

Torabi *et al*. (2016) provided some analytical techniques for the effective implementation of the RA process within the BCMS framework, which includes three steps:

1. Identifying the most potential risk of the organization from the comprehensive list obtained from the literature review,
2. Analyzing the identified risks to identify the impact of each, and
3. Calculating the deviation of the organization's achievements from its predetermined objectives after the occurrence of risk and comparison with risk appetite.

Rabbani et al. (2016) provided a new framework for analyzing the three strategies of "BCM, outsourcing, and insuring," which can be selected using the organization's characteristics. This paper also examines the interrelationships between the organization's desired continuity level in terms of recovery time objective (RTO) and recovery point objective (RPO) indicators, as well as the chosen approach to respond to disastrous conditions.

Buchanan and Buchanan (2006) provided a framework for business continuity management to support BCM planning. Randry et al. (2012, as cited in Zeng & Zio, 2017) presented a model for assessing the maturity of business continuity management programs and examined them in the UAE banking sector (Zeng & Zio, 2017).

To support business continuity management, Zeng and Zio (2017) provide a set of quantitative metrics for business continuity. These include four steps of protection phase, mitigation phase, emergency phase, and recovery phase. Their paper also provides a simulation-based approach for calculating business continuity metrics.

Ostadi et al (2021) uses articles Sahebjamnia (2015) and Zeng and Zio (2017) as the basic articles, a quantitative model is presented in the field of BCM in order to allocate resources after a destructive event in the shortest possible time. The model intends to maximize organizational resilience (or minimize the lack of resilience) and business continuity value (BCV). The model presented in this article is as follows:

$$Min\, f_1 = \sum_{sen=1}^{SEN}\sum_{s=1}^{S}\sum_{r=1}^{T} prob^{sen} * w_s * (L - w_s^{t,sen}) \tag{23}$$

$$Max\, f_2 = 1 - \sum_{sen=1}^{SEN}\sum_{s=1}^{S} prob^{sen} * w_s * (\frac{\vartheta_{s,sen}}{\gamma_s}) \tag{24}$$

Rezaei Soufi *et al*. (2019) offer a new approach to select the most suitable BCP[1]s. They also provide an optimization model aimed at maximizing the level of resilience in the organization while minimizing the establishment cost of selected BCPs. Xing *et al*. (2019, pp.25) propose a DBCA[2] approach, which identifies two factors: "dynamics of the degradation-to-failure process affecting the safety barriers" and "time-dependent profits and tolerable losses." These tend to affect the dynamic behavior of business continuity.

BCP is done according to the needs of the organization, and each organization will have different stages in building BCP. Fani and Subriadi (2019) showed that every organization has methods and changes in the use of BCP and that the organization understands BCP. It should also provide management support, staff capability, costs, and time. Their paper analyzed the suitability of the framework with different types of organizations.

Azadegan *et al*. (2020) assessed the effectiveness of business continuity management and involvement of supply chain in business continuity on reputational and operational damage containment in the face of supply chain disruptions. This study relied on Simons' levers of

1. Business Continuity plan
2. Dynamic Business Continuity Assessment

control framework. Results of data analysis suggested that business continuity management improves reputational damage containment, while supply chain in business continuity improves operational damage containment.

Saad and Elshaer (2020) explored the impact of employees' resilience on two indicators of business continuity, namely perception of job insecurity and creative performance. Moreover, they tested the mediating effects of distributive justice and trust in the organization on this relationship. Results suggested that there is a direct relationship between employees' resilience and business continuity, with distributive justice and trust partially functioning as mediators.

2.3. Risk

According to the literature review in the field of risk management, various methods have been used to measure risk, including Fault Tree Analysis, Event Tree Analysis, HAZOP, and Bow-Tie.

Although roots of research on risk analysis can be traced back to as far as 3200 BC, the risk was not in the construction literature until 1960s. Thus, the term risk was used for the first time by Hertz (1964, as cited by Taroun, 2014) in this field. In the 1970s, statistical methods and Monte Carlo simulation were used for risk analysis, through statistical methods were initially used before employing Monte-Carlo Simulation. In addition, despite knowledge of statistical methods and Monte Carlo simulation in the 1970s, few studies in the field of risk analysis were done in that era (Taroun, 2014).

Rezaie *et al*. (2007) considered the relationships between the uncertainties in the Monte Carlo simulation and the avoidance of impossible situations in the Monte Carlo simulation. In fact, in this paper, risk management was improved by using the extended Monte Carlo simulation with respect to the relationships between uncertainties.

Medina *et al*. (2009) developed an optimization model to minimize costs (including plant costs and the cost of any accident) and consider risk. Hong et al. (2009) examined the potential risk of tunneling excavation using ETA. The results obtained in this paper indicated that ETA is an effective method for quantitative assessment and analysis of potential risks.

Khakzad et al. (2012) analyzed risk using a Bayesian Network approach in a dynamic environment. In other articles, Vileiniskis and Remenyte-Prescott (2017) provided a quantitative framework-based simulation framework for predicting risk through the expansion of the Petri Net model. Zarei *et al*. (2018) assessed the safety risks of city natural gas pressure regulating stations using Bayesian network along with a dynamic and quantitative approach. Zeng and Zio (2018) provided a dynamic risk assessment (DRA) method that enables online estimation of risk indicators.

Mutlu and Altuntas (2019) analyzed risk using integration of FTA method (Fault Tree Analysis) and BIFPET algorithm (Belief in Fuzzy Probability Estimations of Time). The method proposed in this paper can be used in various industries for risk analysis.

Ostadi, B., Sedeh, O. M.,et al. (2020) proposed a new approach to determine the optimal proposed pattern among GenCos in the power market using a hybrid model based on Markowitz model and Genetic Algorithm (GA). In this paper, the risk was considered for the proposed models based on the Markowitz model as an optimization model via the consideration of the risk of acceptance in the market.

In another article, Ostadi, B., Ghaffari, S.,et al. (2020) calculated the probability of the acceptance and the risk of non-acceptance of bid prices in the electricity market. One of the results of Ostadi, B., Ghaffari, S., *et al*.'s (2020) article was that there is no direct relationship between high or low-price intervals and acceptance risk, but the probable data should be analyzed according to the distribution of price intervals.

2.4. Process Safety

According to the literature review in the field of process safety, various methods have been used to measure process safety, including Bayesian Networks (BNs), Dynamic Bayesian Networks (DBN), Fault Tree Analysis (FTA), Event Tree Analysis (ETA) and Papion (BT), HAZOP, expert systems related to HAZOP, and layers of protection analysis method (LOPA) (Amin *et al*., 2019).

Dağdeviren and Yüksel (2008) developed a fuzzy AHP approach to determine the level of faulty behavior risk in work systems and provided a fuzzy analytic hierarchical process (AHP) model for behavior-based safety management. Castillo-Borja *et al*. (2017) proposed a resilience index to deal with lost information to identify safety in a process system. They also proposed a strategy based on Monte Carlo simulation.

Li & Wang et al. (2018) simulated the chlorination process safety management system. They used the system dynamics approach. Jain & Pasman et al. (2018) provide a process resilience analysis framework (PRAF) for risk improvement and safety management. Finally, Zarei *et al*. (2019) evaluated the safety of process systems using a fuzzy Bayesian network (FBN) approach.

3. Research Methodology

Systematic literature review was used to perform this research. The systematic literature review methodology aims to understand how the concepts have evolved, using the papers selected after the systematic literature review process analysis.

Since the purpose of reviewing articles is to provide the best future directions in the mentioned areas to understand the way research is in these areas with different perspectives and to provide conceptual frameworks and the way articles in the studied areas are linked together, the research question is formed:

- What is the relationship between different articles in the areas of resilience, business continuity, risk, and process safety? Can these areas be linked to each other?

In order to collect information, we referred to books, articles, and resources available in the library; searched the World Wide Web; and reviewed theses and dissertations. In this article, first CiteSpace software was used to obtain high-reference articles. Then the obtained article references were used for further research. In addition, reputable resources such as Science Direct, Scopus, Springer-Link, IEEE Xplore, and Google Scholar were used to search for articles.

Co-occurrence network analysis is a suitable method for drawing scientific maps, and this method has been used in various fields to cluster thematic areas and undertake analytical work. In fact, the co-occurrence network is a suitable tool for information analysts and researchers eager to discover and understand the resulting graph. The population and sample of the research were articles in the areas of resilience, business continuity, risk, and process safety, in which the co-occurrence of keywords were searched. In addition, the software used in this article was Gephi, which is the software for visual exploration of networks. As shown in Figure 7, articles were divided into three clusters. The largest cluster was dedicated to topics related to maximizing resilience and business continuity.

4. Classification and Categorization of Conducted Research and Providing a Conceptual Framework for Research

The objective of this section is to examine the relationship between the articles studied in the literature review section and to provide conceptual models. In addition, according to the results of the relationship between articles and conceptual models obtained from their review, articles are clustered using review of co-occurrence of keyword that confirm to the classification obtained in the first part.

Thus, according to the literature review mentioned in the previous section, in the first step the articles were analyzed to determine what is being done in the area of process optimization in organizations. In fact, according to the review of articles in the area of resilience, business continuity, and risk, and their pairwise review in the previous section, three macro approaches were obtained in these three categories: maximizing the value of business continuity and resilience, maximizing process safety, and minimizing risk and the effect of risk factors and uncertainty. Then, conceptual frameworks titled “research house” were formed based on these three categories. In this study, a conceptual analysis was performed on the articles according to the nature, level of research, and the way the research was conducted. After the article review phase, three conceptual models were obtained.

4.1. Maximizing the Value of Business Continuity and Resilience

The purpose of this section is to summarize the articles in which researchers have sought to focus on providing an approach, a method, or a model in order to maximize the value of business continuity or increase the rate of resilience. Therefore, while determining the research area of the research conducted, it has been determined that the level of conducted research in the hierarchy of organizational architecture includes various levels, including resources, process, and the whole organization. In addition, in terms of content, it is determined which of the concepts of risk, resilience, and business continuity is included in the research modeling. Due to the fact that the modeling methods and tools are also effective in model efficiency, in this summary the main tools and theories used are also presented.

Based on the foregoing points, a summary of some studies that have focused on resilience and business continuity is given in Table 1 below.

Table 1. Summary of Business Continuity and Resilience Articles

Research purpose	Area studied	Level of research			Research content			Main tools and theories	Year	Author(s)
		resources	Process	focus on the organization	Risk	Resilience	Business continuity			
Presentation of a model to strategic decision support for support disaster recovery selection with the aim of maximizing the value of the recovery capability of a recovery strategy	Organization	✓		✓	✓		✓	Optimization model	2002	Bryson et al.
Presentation of a criterion for measuring the degree of resilience of a community in an earthquake	Community	✓				✓		Deterministic approach	2003	Bruneau, Michel, et al.(2003,as cited in Hosseini, 2016)
Presentation of a probabilistic approach to assessing resilience	Communities					✓		Probabilistic approach	2004	Chang & Shinozuka
Presentation of a framework for designing, implementing, and monitoring a business continuity management program	No specific area		✓		✓		✓	Conceptual framework	2006	Gibb & Buchanan

Table 1.

Presentation of a genetic algorithm to optimize power recovery after an earthquake	Power company					✓		Optimization model	2007	Xu et al.
Identification of static economic resilience and dynamic economic resilience	Economic				✓	✓		Deterministic approach	2007	Rose
Presentation of a framework to support business continuity plans modeling and analysis from an organizational perspective	Organization	✓	✓	✓	✓		✓	GR[1] framework for risk analysis and TDR[2] model	2008	Asnar & Giorgini
Presentation of a conceptual framework for system resilience	No specific area	✓		✓	✓	✓		Conceptual framework	2009	Kahan et al. (2009,as cited in Hosseini, 2016)
Presentation of conceptual framework for resilience engineering	No specific area			✓	✓	✓		Conceptual framework	2009	Madni & Jackson
Presentation of how business continuity management works and the difference between implementation and non-implementation	Urban infrastructure						✓	Analytical	2010	Kawamura & Nakatani
Presentation of an approach to improve resilience	Internet networks Communication network	✓				✓		Conceptual framework	2010	Sterbenz et al.
Determining the effectiveness of business continuity management program by measuring resilience	Organization			✓		✓	✓	Analytical	2010	Stephenson
Presentation of a comprehensive conceptual model to quantify disaster resilience, which includes both loss estimation models and recovery models	Health care	✓				✓		Deterministic approach	2010	Cimellaro et al.
Presentation of a framework for resilience and survivability of communication networks	Internet networks					✓		Simulation model	2011	Sterbenz et al.
Prediction of resilience by extending a multi-dimensional approach	No specific area			✓		✓		Deterministic approach	2011	Zobel
Presentation of an approach for providing a measure of resilience in the presence of multiple related disaster events	No specific area					✓			2014	Zobel & Khansa
Examining the UAE banking sector by presentation of a business continuity management maturity model	Organization			✓	✓		✓	Presenting a maturity model appropriate to BCM using a two-step approach	2012	Randeree et al.
Presentation of a new multi-stage framework to analyze infrastructure resilience	Urban infrastructure	✓				✓		Probabilistic approach	2012	Ouyang et al.
Presentation of a community resilience framework for an earthquake-prone region	Community				✓	✓		Conceptual framework	2012	Ainuddin & Routary (2012,as cited in Hosseini, 2016)

1. Goal-Risk
2. Time Dependency and Recovery

Table 1.

Presentation of a method to evaluate resilience engineering in industry	Process industry			✓	✓	✓		Semi-quantitative method	2012	Shirali et al.
Presentation of a simulation model to evaluate supply chain resilience and improve supply chain resilience	Transportation	✓	✓			✓		Simulation models	2012	Carvalho et al. (2012,as cited in Hosseini, 2016)
Presentation of a dynamic simulation method to simulate supply chain resilience	Supply chain				✓	✓		Simulation models	2012	Virginia et al. (2012,as cited in Hosseini, 2016)
Presentation of a model for assessing infrastructure resilience	Urban infrastructure					✓		Fuzzy logic models	2012	Muller et al. (2012,as cited in Hosseini, 2016)
Presentation of a model for assessing organizational resilience	Organization	✓	✓	✓		✓		Fuzzy logic models	2013	Aleksic et al. (2013,as cited in Hosseini, 2016)
Identification of psychological factors to recover from temporary trauma or unexpected catastrophic events	Organization			✓		✓		Structural-based models	2013	Azusa & Hiroyuki
Measurement of resilience-based network component importance	Networks					✓		Probabilistic approach	2013	Barker et al.
Presentation of a framework for assessing the resilience of regional road-based transportation network	Transportation network					✓		Conceptual framework	2013	Omer et al.
Presentation of an initial framework for business impact analysis in organizations based on some effective multi attribute decision making (MADM) techniques	Organization	✓		✓	✓		✓	Conceptual framework / ANP and fuzzy DEMATEL	2014	Torabi et al.
Presentation of different approaches to defining and evaluating resilience / presentation of a dynamic resilience metric	Urban infrastructure				✓	✓		Deterministic approach	2014	Francis & Bekera (2014,as cited in Hosseini, 2016)
Presentation of a conceptual framework for assessing livelihood resilience	Society-Ecology	✓		✓		✓		Conceptual framework	2014	Speranza et al.(2014,as cited in Hosseini, 2016)
Presentation of a mathematical model for evaluating and optimizing airport resilience with the aim of maximizing resilience on the airport's runway and taxiway network	Airport pavement network	✓				✓		Optimization model	2014	Faturechi et al. (2014,as cited in Hosseini, 2016)
Presentation of a multi-stage stochastic mathematical model for quantifying and optimizing travel time resilience in road networks	Transportation					✓		Optimization model	2014	Faturechi & Miller-Hooks (2014,as cited in Hosseini, 2016)
Presentation of a two-stage stochastic programming model for the resilience analysis of transport network	Metro networks	✓				✓		Optimization model	2014	Jin et al. (2014,as cited in Hosseini, 2016)
Evaluation of the performance of safety and human resources by considering the factors of RE	Petrochemical plant			✓		✓		Optimization model	2014	Azadeh, A., Salehi, V., Ashjari, B. et al.
Examination of factors affecting the resilient level	Petrochemical plant			✓	✓	✓		Fuzzy cognitive map	2014	Azadeh, A., Salehi, V., Arvan, M. et al.

Table 1.

Formulation of a bi-level optimization model for network recovery and demonstration of a solution approach for that optimization model	Transportation	✓				✓		Optimization model	2014	Vugrin et al. (2014,as cited in Hosseini, 2016)
Presentation of a simulation-based model for measuring the resilience indicators in a railway transport system	Transportation					✓		Simulation model	2014	Adjetey-Bahun et al.
Presentation of a time-dependent model for resilience and associated stochastic metrics in a waterway transportation context	Water way network				✓	✓		Optimization model	2014	Baroud et al.
Presentation of a general approach to determining system resilience by relating a disruptive event to component performance and ultimately to system performance	Transportation	✓				✓		Probabilistic approach	2014	Pant et al.
Presentation of a probabilistic metric for assessing infrastructure resilience against earthquake	Urban infrastructure					✓		Probabilistic approach	2015	Franchin and Cavalieri
Obtainment of resilience using metrics network operation cost	Urban road networks					✓		Optimization model	2015	Bhavathrathan & Patil
Minimization of the weighted sum of key products' loss of resilience / minimization of the weighted sum of recovery times / Proposition of a new resource allocation model for IBCDRP[1] framework	Resource allocation	✓		✓	✓	✓	✓	Multi-objective Mixed Integer Linear Programming	2015	Sahebjamnia et al.
Presentation of a mathematical model for metrics assessment of railway infrastructure to maximize resilience in the rail network	Transportation					✓		Optimization model	2015	Khaled et al (2015,as cited in Hosseini, 2016)
Maximization of the NRI and minimization of total transportation cost	Supply chain network					✓		Optimization model	2016	Dixit et al
Risk assessment in the implementation of business continuity management system in an organization/ providing needed resources to respond to the happened risk with regards to the results of business impact analysis and benefit/cost analysis	Organization	✓		✓	✓	✓	✓	Conceptual framework	2016	Torabi et al.
Presentation of a framework for analyzing different strategies/ Examination of the interrelationships between the organization's desired continuity level in terms of recovery time objective and recovery point objective indicators, and the chosen approach to respond to disastrous conditions	Organization			✓			✓	Conceptual framework / Fuzzy based method	2016	Rabbani et al.

1. Integrated business continuity and disaster recovery planning

Table 1.

Presentation of a set of quantitative business continuity metrics to determine integrated risk management strategies	Organization			✓	✓		✓	Event Tree Model/ Semi-Markovian model	2017	Zeng & zio
Investigation of the interactions of resilience engineering (RE) and managerial and organizational factors	Gas refinery	✓		✓		✓		Optimization model	2017	Azadeh et al.
Resilience optimization that incorporates an improved quantitative measure of resilience and a comprehensive set of resilience enhancement strategies for process design and operations / maximization of resilience under the worst-case of the accessibility of process units and Minimization of the total capital cost	Process systems		✓		✓	✓		Multi-objective two stage adaptive robust mixed integer fractional programming model	2018	Gong & You
Interaction between organizational resilience and required resources/ presentation of a new model for creating organizational resilience with the ability to respond to multiple disruptive events	Resource allocation	✓		✓	✓	✓	✓	Integrated business continuity and disaster recovery planning model	2018	Sahebjamnia et al.
Network design with the aim of minimizing costs while meeting system resilience constraints	Network					✓		Optimization model	2018	Zhang et al
Presentation of an approach for resilience analysis as a time-dependent function in the system	Transportation					✓		Deterministic approach	2012	Henry & Ramirez-Marquez
Presentation of a model for evaluating business continuity in the relevant organization with the aim of maximizing the value of business continuity and maximizing resilience	Resource allocation	✓		✓	✓	✓	✓	Optimization model	2021	Ostadi et al.
Presentation of a new framework for determining the optimal number of machines and manpower using fuzzy logic	Resource allocation	✓	✓					Fuzzy logic model	2018	Ostadi et al.
Developing a discrete-event simulation model for improving the quality of services in urology unit at a kidney center	Health	✓	✓					Discrete-event simulation model	2019	Mokhtarian Daloie & Ostadi
Evaluation of a time-dependent resilience metrics	Infrastructure network	✓				✓		Optimization model	2019	Almoghathawi & Barker
Presentation of a new approach to select the most suitable business continuity planning / Maximization of the resilience level of the organization and minimization of the establishment cost of selected business continuity planning	Organization	✓		✓	✓	✓	✓	Optimization model	2019	Rezaei Soufi et al.
Presentation of a simulation-based framework for calculating time-dependent business continuity metrics/ evaluation of dynamic business continuity	No specific area			✓	✓		✓	Simulation-based framework/ stochastic price model/ installment model	2019	Xing et al

Table 1.

Presentation of a business continuity plan framework with the objective of adapting the framework to different types of organizations	Organization			✓	✓		✓	Conceptual framework	2019	Fani & Subriadi
Evaluation of a model for survival of a process system under upset conditions using the process resilience analysis framework / Minimization of total annualized cost and Maximization of expected revenue / Resource allocation	Process system	✓	✓		✓	✓		Mixed integer nonlinear programming	2019	Jain et al.
Evaluation of the effectiveness of business continuity management (BCM) and involvement of supply chain in business continuity (SCiBCM) on reputational and operational damage containment in the face of supply chain disruptions	Organization/ Supply chain			✓	✓		✓	Simons' levers of control framework/ vignette-based experiment	2019	Azadegan et al.
Optimal allocation of budget with the aim of maximizing resilience	Network	✓				✓		Optimization model	2020	Najarian & Lim
Introduction of a new set of resilience metrics based on the concept of reliability with a system modeling approach	No specific area					✓		Simulation model	2020	Yarveisy et al.
Presentation of a conceptual model to improve hospital performance	Health					✓		Presentation of a conceptual model	2020	Pishnamazzadeh et al.
Examination of business continuity and response of 50 world-leading companies to the COVID-19 emergency and provision of a framework of actions undertaken by world-leading companies	Health						✓	Conceptual framework	2021	Margherita & Heikkil
Presentation of a method to integrate risk assessment and business continuity management in the public crisis management sector	Organization			✓	✓		✓	Semi-quantitative method	2021	Hassel & Cedergren
Presentation of two-stage risk-averse and risk-neutral stochastic optimization models with the objective of the maximization of system resilience	Transportation				✓	✓		Optimization model	2021	Alkhaleel, B. A., & etal.
Network data envelopment analysis (DEA) with the objective of "performance evaluation of process industries' risk-based resilience"	Networks		✓		✓	✓		Data envelopment analysis (DEA)	2021	Namvar& Bamdad

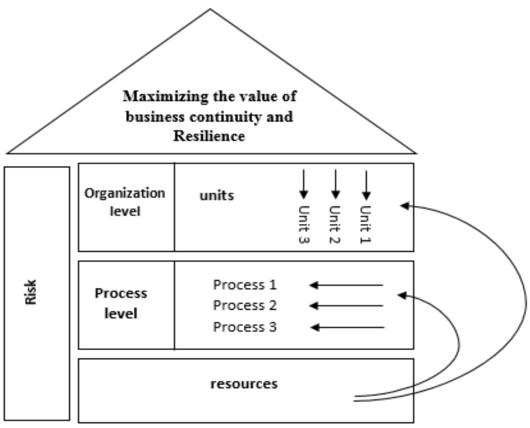

Figure 4. Conceptual Framework for Maximizing the Value of Business Continuity and Resilience

4.2. Maximizing Process Safety and the Effect of Risk and Resilience Factors

In this section, a summary of those articles is given in which researchers have sought to focus on providing an approach, method, or model in order to maximize process safety and on the effect of risk and resilience factors. Therefore, while determining the research area of the research conducted, the focus is on the articles whose levels of research and modeling has been at the level of process. In addition, in terms of research content, it has been determined which of the concepts of uncertainty, resilience, risk, and process safety are included in the research modeling. Due to the fact that in modeling, the modeling methods and tools are also effective in model efficiency, the main tools and theories used are also presented in this summary. Taking into account these points, Table 2 presents the summary of some studies that focus on resilience, risk and process safety.

Table 2. Summary of Process Safety Articles

research purpose	Area studied	Level of research	Research content				Main tools and theories	Year	Author(s)
		Process	uncertainty	Resilience	Risk	Process safety			
Determination of the level of faulty behavior risk (FBR) in work systems / presentation of a model for behavior-based safety management	Manufacturing organization	✓			✓	✓	Presentation of a fuzzy AHP approach and fuzzy analytic hierarchy process (AHP) mode	2008	Dağdeviren & Yüksel
Identification of safety in a process system	Process system	✓		✓		✓	Presentation of a strategy based on Monte Carlo simulation	2017	Castillo-Borja etal
Presentation of a new method for evaluating and managing human factors	Process industry		✓		✓	✓	The set pair analysis method / SPA[1]-Markov chain risk prediction model / ABC analysis and the "S-O-R" model	2018	Xie & Guo
Risk assessment of an industrial non-routine operation process using job safety analysis and a revised petri net	Chemical plant	✓			✓	✓	Integration of Petri net model and job safety analysis (JSA) method	2018	Li & Cao et al.
Simulation of a process safety management system	Industrial	✓				✓	Presentation of system dynamics approach	2018	Li & Wang et al.
Identification of resilience metrics for improved process-risk decision making / advanced risk assessment and accurate and informed decision making	Process industry	✓		✓	✓	✓	Ordinal alpha ، Kruskal-Wallis, polychoric correlations	2018	Jain & Mentzer et al
Analysis of process resilience / presentation of a framework for analyzing process resilience in the areas of risk improvement and safety management	Chemical industry		✓	✓	✓	✓	Presentation of a framework	2018	Jain & Pasman et al.
Assessing the safety of process systems by developing a fuzzy Bayesian network (FBN) method	Process systems	✓	✓		✓	✓	Presentation of a fuzzy based BN approach	2019	Zarei et al

1. set pair analysis

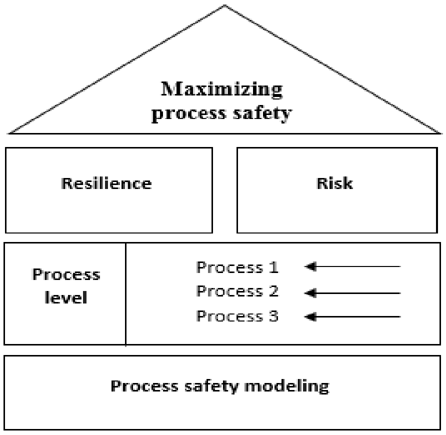

Figure 5. Conceptual Framework for Maximizing Process Safety and the Effect of Risk and Resilience Factors

4.3. Minimizing Risk and the Effect of Uncertainty

In this section, a summary of articles is provided in which researchers have sought to focus on providing an approach, method, or model in order to minimize the risk and the effect of uncertainty. Therefore, while determining the research area of the research conducted, the focus is on the articles whose levels of research and modeling has been at the level of process. In addition, in terms of research content, it has been determined which of the concepts of uncertainty and risk are included in the research modeling. Due to the fact that in modeling, the modeling methods and tools are also effective in model efficiency, the main tools and theories used are also presented in this summary. Taking into account these points, Table 3 presents the summary of some studies that focus on risk and uncertainty.

Table 3. Summary of Risk Articles

Research purpose	Area studied	Level of research	Research content			Main tools and theories	Year	Author (s)
		Process	uncertainty	Resilience	Risk			
Fatality risk assessment and modeling of drivers responsibility in traffic accidents / investigation of accident and safety statistics to identify the factors affecting the increase in accident risk	Transportation				✓	Use of relative risk, Lorenz curve and Gini index / Logistic regression model	2002	Abdalla
Use of the Monte Carlo simulation method to improve risk management considering the interactions of uncertainties	No specific area		✓		✓	Monte Carlo Simulation / rotary algorithm	2007	Rezaie et al.
Development, definition, and explanation of two new quantitative methods of risk assessment	Industrial productive				✓	The decision matrix risk-assessment (DMRA) technique/ The proportional risk-assessment (PRA) technique	2008	Marhavilas & Koulouriotis
Presentation of a model for optimization taking into account cost and risk	Chemical plants				✓	Presentation of a mathematical model	2009	Medina et al.

Table 3.

Application of Bayesian theory in quantitative risk assessment and its application in dynamic risk assessment to prevent accidents	No specific area				✓	Event tree model / Bayesian theory	2009	Kalantarnia et al.
Examination of risk probability of a tunneling excavation and adoption of event tree analysis (ETA) to determine the risk in the initial design phase of the tunnel	Underwater tunnel				✓	Event tree analysis	2009	Hong et al
Presentation of a new incident tree method/ Quantitative risk assessment	Transportation		✓		✓	Incident tree model (ITA) and fuzzy incident	2010	Wang et al
Presentation of a hybrid method using quantitative risk assessment methods	Power provider industry				✓	The proportional quantitative risk-assessment technique (PRAT), the time-series stochastic process (TSP), and the method of estimating the societal-risk (SRE)	2012	Marhavilas & Koulouriotis
The application of updated BT in dynamic risk assessment	Manufacturing industry				✓	Bow-Tie	2012	Khakzad et al.
Presentation of a simulation framework based on the Petri net model to perform quantitative risk prognostics by extending the Bow-Tie model	Underground passenger lift	✓			✓	Petri Net and Bow-Tie models	2017	Vileiniskis & Remenyte-Prescott
Presentation of a multi-objective optimization method considering process risk correlation for project risk response planning	No specific area	✓			✓	Presentation of an optimization model/ non-dominated sorting genetic algorithm II	2018	Wu et al.
Safety risk assessment of city natural gas pressure regulating stations using a dynamic and quantitative approach and dynamic modeling of the cause-and-effect model using Bayesian network	Process system	✓			✓	Bayesian network	2018	Zarei et al.
Process risk assessment / presentation of a method for reviewing the bow tie method considering interdependence / use of Monte Carlo simulations to estimate probability	Process system	✓			✓	Development of a bow tie method and implementation of bow tie model using Monte Carlo simulation	2018	Guo et al.
Online estimation of risk indexes using data collected during operation with dynamic risk assessment method	No specific area				✓	Hierarchical Bayesian model / Event Tree (ET)	2018	Zeng & Zio
Presentation of an approach based on machine learning and use of the DNN model for a drive-off scenario involving an Oil and Gas drilling rig	No specific area				✓	Machine learning / deep neural network	2019	Paltrinieri et al.
Improvement of the performance of the FMEA method using the integration of the FTA method and the BIFPET algorithm	Production systems	✓			✓	Integration of FMEA, FTA, and BIFPET methods	2019	Mutlu & Altuntas

Table 3.

Presentation of a new approach to risk assessment by the consideration of the co-occurrence of risk factors due to the effect of co-occurrence of risk in intensifying or reducing the severity of risk	Chemical plant				✓	Monte Carlo simulation	2020	Ostadi & Abbasi Harofteh
Presentation of a new approach for the determination of the optimal bidding patterns among GenCos in the deregulated power market	Power market				✓	Hybrid of Markowitz Model and Genetic Algorithm (GA)	2020	Ostadi, B., Sedeh, O. M.,et al.
Presentation of a conceptual model based on the simultaneous analysis of the probabilistic distribution for historical data	Power market				✓	Presentation of a conceptual model	2020	Ostadi, B., Ghaffari, S.,et al.

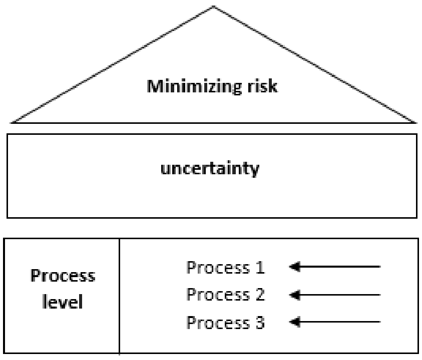

Figure 6. Conceptual Framework for Minimizing Risk and Effect of Uncertainty

In the next step, the discussion of risk in the resource allocation section and the discussion of resilience and continuity in the whole of process optimization were considered in the resource allocation of operational processes. Moreover, in another analysis, the co-occurrence analysis of the research areas focused on the studied areas was done. In fact, the relationship between the issues of resilience and continuity and risk was obtained. That is, if one article had problems of risk and resilience and another article had problems of continuity and resilience, their co-occurrence relationship was examined. After reviewing the articles, the key sentences of each article were extracted and then the closed codes were formed according to the key sentences. Therefore, according to the studied articles and the closed codes extracted from the articles, their co-occurrence was obtained through MAXQDA software.

Table 4. Closed Codes of Articles

No.	ID	Label (closed codes)	Frequency
1	C01	Application of resilience / business continuity with case study	41
2	C02	Application of risk with case study	12
3	C03	Application of process safety with case study	5
4	C04	Conceptual framework for resilience	16
5	C05	Conceptual framework for business continuity	8
6	C06	Examination of resilience at organization level	18
7	C07	Examination of business continuity at organization level	7
8	C08	Examination of resilience at process level	3
9	C09	Examination of business continuity at process level	1
10	C10	Examination of process safety at process level	6
11	C11	Presentation of resilience quantitative assessment models	31
12	C12	Presentation of business continuity quantitative assessment models	5
13	C13	Optimal allocation of limited resources	25
14	C14	Deterministic approach for resilience	^8
15	C15	Probabilistic approach for resilience	6
16	C16	Quantitative assessment of risk	14
17	C17	Quantitative assessment of process safety	4
18	C18	Presentation of hybrid techniques of risk assessment	3
19	C19	Resilience/ business continuity assessment with considering of risk	25
20	C20	Process safety / risk assessment with resilience analysis framework	3
21	C21	New definitions and measurement of resilience	5
22	C22	Risk assessment with the consideration of uncertainty	2

Table 5. Closed Codes Co-Occurrence of Articles

No.	Source	Target	Frequency	No.	Source	Target	Frequency	No.	Source	Target	Frequency
1	C11	C01	22	25	C04	C13	7	49	C19	C14	2
2	C11	C14	2	26	C04	C19	7	50	C19	C15	1
3	C11	C04	3	27	C19	C08	2	51	C04	C08	1
4	C11	C05	2	28	C04	C21	1	52	C13	C12	1
5	C11	C06	10	29	C04	C15	3	53	C19	C12	4
6	C11	C08	2	30	C05	C06	3	54	C19	C07	6
7	C11	C13	14	31	C05	C12	3	55	C21	C15	1
8	C11	C19	10	32	C05	C14	1	56	C07	C12	1
9	C11	C07	1	33	C05	C13	5	57	C15	C21	1
10	C11	C21	1	34	C05	C19	8	58	C02	C18	3
11	C14	C01	6	35	C05	C07	5	59	C16	C02	9
12	C04	C01	14	36	C06	C13	9	60	C16	C22	1
13	C05	C01	2	37	C06	C19	11	61	C02	C22	1
14	C06	C01	6	38	C06	C14	1	62	C18	C22	1
15	C08	C01	2	39	C06	C07	1	63	C10	C20	2
16	C13	C01	14	40	C06	C12	3	64	C10	C17	4
17	C19	C01	11	41	C06	C08	1	65	C03	C10	4
18	C15	C01	5	42	C08	C13	2	66	C03	C20	2
19	C07	C01	2	43	C08	C19	2	67	C03	C17	3
20	C12	C01	2	44	C13	C19	10	68	C09	C01	1
21	C21	C01	2	45	C13	C14	2	69	C09	C05	1
22	C14	C04	2	46	C13	C15	2	70	C09	C07	1
23	C14	C21	1	47	C13	C08	2	71	C09	C13	1
24	C04	C06	5	48	C13	C07	4	72	C09	C19	1

Then, Gephi software was used to draw the co-occurrence network of keywords and their network including the three obtained clusters. In fact, the three clusters achieved confirmed the three categories obtained in the previous section.

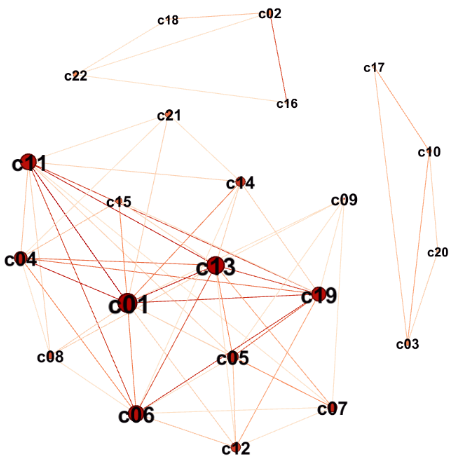

Figure 7. Vocabulary Co-Occurrence Network

Therefore, according to the network in Figure 7, three clusters were obtained. By evaluating the articles according to the tables of closed codes and their co-occurrence, it is concluded that:

- More than 50% of resilience and business continuity and risk articles had a case study.
- 30% of resilience articles and 53% of business continuity articles had a conceptual framework.

- 34% of resilience articles and 47% of business continuity articles were at the organization level.
- 6% of resilience articles, 7% of business continuity articles, and 75% process safety articles were at the process level.
- More than 50% of resilience articles and 33% of business continuity articles had quantitative assessment models.
- 37% of resilience and business continuity articles focused on optimal resource allocation.
- 9% of articles defined and measured resilience in a new method.
- 15% of resilience articles had a deterministic approach and 11% of them had a probabilistic approach.
- 82% of risk articles were evaluated quantitatively.
- 37% of resilience/ business continuity articles were done with the consideration of risk.
- 12% of process safety / risk assessment articles were done according to resilience.
- 12% of risk assessment articles were done with the consideration of uncertainty.
- 33% of articles presented models of resilience quantitative assessment with a case study.
- 38% of articles included “quantitative assessment of process safety with case study.”

According to research conducted, the research gaps are as follows.

- Previous models have measured resilience and continuity at the organization level rather than the process level.
- Risk has been included in the allocations, but this risk has not been seen in terms of the returns that can occur in the allocation. In such articles, resource risks are not considered according to the type of resources.
- In previous similar studies, the issue of allocation has not been included in modeling the nature of operations and activities. In fact, they have not considered the hypothesis of prerequisites and concurrence of activities.
- Previous studies have not considered different combinations in allocation (portfolio of resource allocation) and have emphasized the performance of the organization or process.

In addition, in the area of risk, most of the articles have been done quantitatively and via the case study method to identify and assess the risk in an industry. In fact, most studies have provided evaluation methods, and they have often been based on mathematical and optimization models. The methods used in the risk-related studies cause weaknesses that limit their use, so better methods should be used to measure risk. In the area of resilience, most articles have been qualitative and the focus has been more on conceptualization and presentation of a conceptual model. There is no exact method to measure process resilience. Therefore, the use of mathematical modeling with a quantitative approach in resilience is a possible topic that can be researched. In addition, system recovery and its role in infrastructure systems resilience have attracted much attention.

5. Conclusion

This study aimed to provide an overview of the subject by examining the literature on “resilience,” “business continuity,” “risk,” and “process safety,” analyzing major trends, as well as highlighting gaps and providing future research recommendations. In this context, 90 journal articles published up to the end of 2020 were examined. Journal articles were examined under three headings as literature reviews, categorization of conducted research, and providing a conceptual framework for research. Given the importance of the issue of resilience and continuity and risk in organizations due to crises and disruptions on them, the need to investigate and find the relationship between them for better management in organizations was strongly felt. Therefore, in the present article, besides reviewing the articles, the relationship between the mentioned areas and the existing research gaps were discussed. In addition, according to the category of articles, conceptual frameworks were provided to better understand these concepts. There were also few studies that analyzed articles in the mentioned areas together and provided an idea for future research directions for the mentioned cases. The reason is that conducting research on resilience and business continuity by considering risk is a new problem that is very important for organizations to address. The increasing number of incidents and crises in societies and organizations has highlighted the need to pay attention to understanding the structure and conceptual frameworks of these areas in order to raise the awareness of researchers. It can also help researchers understand the overview of the scientific framework of the areas and also to select important topics in these areas. Thematic templates and maps are a suitable method to organize, understand, and search for articles and thesis. The examination of the co-occurrence of closed code showed that “articles presented with quantitative resilience assessment models and case studies” had the highest repetition. The purpose of this paper was to provide a classification and a conceptual framework in the areas of business continuity, resilience, and risk. The articles were also divided into three categories, maximizing the value of business continuity and resilience, maximizing process safety, and minimizing risk. This led to the formation of three conceptual frameworks.

Measurement of resilience and continuity and resource allocation can also be considered at the process level. The concepts of business continuity, resilience, and risk are used in many areas, but there are many hidden layers that have not yet been addressed. During the research, an idea was created that according to the review of the research, research gaps were obtained.

Therefore, given the research gaps, there is a need for a framework that can consider the issue of resilience, continuity, and risk, when resources are allocated to the process. In this framework, the following question should be answered:

- How can the resources required in operational processes be optimally allocated during the life cycle of the processes so that the process has optimal and acceptable performance (process continuity and process resilience)?

This article intended to obtain the category of studied articles, provide conceptual frameworks resulting from article analysis, and present a conceptual model. Finally, according to the proposed conceptual model and reviewing the articles conceptually, the following conceptual framework was created for future research.

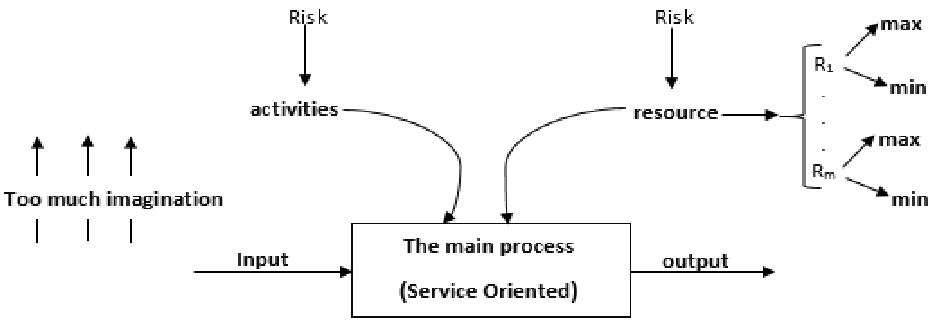

Figure 8. Conceptual Framework of Research

According to Figure (8), there is a main process that is service-oriented. Normally, the client requests the service and exits after the operation. However, if too much input is allowed, a crisis will happen. This causes some processes to fail to respond to those inputs and a lack of process planning occurs. Therefore, the process must be able to respond to service requests. This ability can be measured through process continuity and process resilience. There are also a number of activities and resources in this process, the function of which is based on resource allocation. Each resource has a minimum and maximum amount as well as internal and external resources. If the process has too much input, it will usually have to get external resources. Activities and resources are also associated with risk. Therefore, it is necessary to allocate resources in the process in such a way that the process has its optimal performance in different conditions. In these different situations, there may be risks regarding which the basis of process performance should be based on process resilience and process continuity.

In processes based on the different outputs that exist, how the available resources can be optimally allocated so that more outputs can be produced due to the lack of resources. Therefore, the process must be continuous, a concept that has come to be called process continuity.

Furthermore, in different conditions (normal situation or with many inputs and requests in a process), the process can have different modes of its own resilience. Therefore, with this view, we can obtain a concept called process continuity and process resilience. Thus, researchers can do resource allocation modeling in the future research by considering risk, resilience, and business continuity.

Based on the foregoing points, the following lines of research can be proposed for future research:

- In operational processes, as process risks are significant, they affect the output of process and process service continuity. Then, how can the continuity of process service be maximized in such circumstances by optimally allocating resources?
- How can a process be kept as resilient as possible if the process faces high/unusual output or a shortage of process resources?

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