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Adaptive E-Business Continuity Management: Evidence from the Financial Sector

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Abstract. This paper focuses on business continuity management in organizations that use modern e-business technologies: the Internet, mobile computing, e-services, and virtual infrastructure. The aim is to make the shift from traditional Business Continuity Management (BCM) towards "e-Business Continuity Management" (e-BCM) suitable for modern technological environments. We have defined a comprehensive framework for the implementation of an adaptive e-BCM adjustable to changes in the business environment. The framework consists of practical steps for defining elements of a business continuity management system: business impact analysis, risk assessment, and a business continuity plan. We have implemented and evaluated the framework within three financial organizations. The key finding is that Business Impact Analysis and the continual improvement of the Business Continuity Management System are the driving factors for the effective establishment of an adaptive e-BCM. The proposed framework is general, and can be applied to any organization that uses modern e-business technologies.

Keywords: E-Business Continuity Management, Business Impact Analysis, Business Continuity Plan, ISO 22301.

1. Introduction

E-business is based on modern information and communication technologies (ICT): the Internet, mobile technology, cloud computing, and next-generation networks, as well as new concepts, such as the Internet of things, Big Data, and ubiquitous computing[1]. In addition to their numerous benefits[2], modern e-business technologies pose new risks to the business, and particularly to business continuity[3]–[5] and information security, given the amount, speed of creation, and availability of information. The more dependent an organization is on modern e-business technologies, the more it becomes vulnerable to the impacts of all types of incidents[6]. The use of modern e-business technologies creates business and information systems that are complex and are considered inherently risky[7]. One of the objectives of business continuity in such circumstances becomes the ability to adapt to such emerging risks, so as to protect these naturally risky systems[7].

Literature data in the field of BCM offers different frameworks and implementation approaches that address the various aspects of BCM. However, a general framework that could define practical steps for the establishment of business continuity among organizations that use modern e-business technologies is lacking. Furthermore, companies' implementation details and results are often kept confidential, hence organizations are struggling to find experiences and practical guidelines that would help them develop their own adaptive e-BCM strategies.

The primary goal of our research is to explore the possibilities of improving business continuity management through the development and evaluation of a framework that will facilitate the establishment of successful e-BCM. Drawing on the definition of business continuity[8], we consider e-business continuity as the ability of an organization to continue the delivery of electronic services at acceptable, predefined levels of reliability and availability following a disruptive incident. Since e-business technologies are rapidly evolving, the proposed framework should be flexible and adjustable to changes in organizations' business environments. Our framework, defined in [9], has been implemented and used in three organizations active in the financial sector in Serbia (see Table 2). This research paper focuses on the evaluation of the proposed framework. The evaluation was performed using basic statistical analysis and Partial Least Squares Structural Equation Modeling (PLS-SEM).

2. Literature Overview

2.1. Business Continuity Management

Business continuity management (BCM) focuses on possible internal and external risks and their impacts on business processes. As such, Standard ISO 22301:2014[8] defines BCM as a holistic management process that identifies potential threats to a company and its impacts on business operations. It provides a framework for building organizational resilience with the ability to effectively respond by safeguarding the interests of its key stakeholders, reputation, brand, and value-creating activities.

The importance of implementing BCM strategies within the life cycles of an enterprise causes evaluation and changing of BCM permanently, both within academia and practitioners.

The relevant literature from publicly available databases offers different frameworks and implementation approaches that address the various aspects of BCM. After analyzing the relevant sources, we have identified the following types of available BCM research papers:

1) General guidelines, applicable to arbitrary industries (e.g., [10], [11], [20], [12]–[19]);

2) Frameworks enriched by statistical and mathematical quantitative calculations (e.g., [21]–[24]

3) Literature that addresses specific industries, business issues, and requirements (e.g., [25]–[28]);

4) The impacts of nature and human destructions on cities (e.g., [29]–[31]).

The first group of BCM research papers recommends general frameworks and implementation approaches that are applicable in arbitrary industries. In the study[10], with reference to [8], the author presents a comprehensive review of a holistic framework for BCM, with a guide for its implementation. Moreover, the author concludes that the proper implementation of a BCM must be aligned with all its key products and processes for an enterprise. The paper[11] presents a systematic framework for the BCM implementation based on the concept of an "always on" business. The model explains that today's organizations are using continuous computing technologies to offer greater availability and reliability to their customers.

Complexity and changes of business processes, roles, relationships and benefits of new technologies force business systems to reinvent existing BCM strategies and adapt them to new conditions and environments[12]. The author suggests the incremental concept, which includes three types of strategies: process-centric, program-centric, and management resilience management. For each of these strategies, the author proposes a list of specific techniques.

IT infrastructure, as an important and critical factor in overall enterprise business, is the subject of interest of BCM as well. One of the first comprehensive frameworks for IT infrastructure, proposed in 2006[13], emphasizes the importance of aligning IT infrastructure, data, and services within overall business strategy and all components of the BCM strategy. The severity of IT incidents in modern BCM strategies is pointed out in [14]. The proposed framework for information system continuity management (ISCM) includes external requirements, management support, organizational alertness, and embeddedness to perceive and minimize the business impacts of ISCM.

In the second group of BCM papers, the researchers propose frameworks enriched by statistical and mathematical quantitative calculations. In [21], the authors used a framework and interactive model for making a decision within the resource allocation problem. They applied the concept in a gearbox manufacturer enterprise successfully. The same authors present a framework for estimating the business impact analysis (BIA) [22], which uses multi-parameter decision-making techniques. The evaluation of the framework was performed within an auto part manufacturing enterprise. An integrated BCM framework in[23] uses quantitative metrics through the protection, mitigation, emergency, and recovery phases, and applies them to a critical lightening disruptive event at an oil storage tank farm. In [24], the authors propose the use of a mathematical programming model as a decision support tool for the successful development of disaster recovery plans.

The third identified group of BCM papers presents implementation approaches that address specific industry, business issues, or business requirements. In [25], the authors implemented a wide quantitative study in 75 automobile parts markers in disaster-prone regions, and introduced a new term - Supply Chain Cooperation (SCC) - to the Business Continuity Plan (BCP). They confirm that BIA is the cornerstone of BCP, as it has a powerful effect on other BCP factors and components. The paper [26] describes the concepts of disaster recovery and data replication plan in The Medical Record Company. The authors in [27] introduce a new concept called "Area BCP", which addresses disaster risk management in industrial agglomerated areas as a whole. The authors propose a framework for coordinated damage mitigation measures and recovery actions, which involves all the business stakeholders in a certain area. The paper [28] focuses on supply chain business continuity issues which, as authors argue, can be applied to any industry.

The fourth type of BCM papers focuses on the impacts of nature and human destructions on cities. Paper [29] focuses on the risk assessment process (RA) that is, in addition to BIA, one of the fundamental components of BCM. The authors propose an enhanced risk assessment framework by adjusting it to BCM needs. They evaluated the framework in a real service organization in charge of disaster management services in the city of Tehran, Iran. Another study [30] focuses on the Smart City infrastructure for the Olympic Games in Japan in 2020. Authors elaborate aspects of security, convenience, maintenance, etc. of the city for the upcoming Games, and how to maintain the continuity of city life after their end.

The majority of papers present practical implementations of frameworks within companies, classified as large ones. It seems that small and medium-sized enterprises (SMEs) have fallen out of interest although they, for example, represent a share of over 95% in the European Union [32]. In [31], the authors discuss the availability of BCM support for SMEs, including the environmental impacts on BCM in risks areas.

After analyzing the four identified types of relevant BCM papers, we have concluded that the practical steps in establishing business continuity in organizations that use modern e-business technologies are lacking. The following common issues have been identified in existing business continuity frameworks and implementation approaches:

1) their focus is solely on definition and planning of business continuity programs [13] or solely on one aspect of business continuity management[22], [24], [26], [29];

2) there is a lack of specific steps in defining business continuity management [18]–[20], [24], [27], and, more specifically, there is a lack of practical steps for business impact analysis and risk assessment[16], [17], which are essential components of BCMS;

3) the approach is too specific for a particular industry or line of business[27], [28]; and

4) the approach is too complicated to implement in an arbitrary organization [22], [24].

We have attempted to address all of these issues using the proposed framework [9] for the establishment and continuous improvement of e-BCM, tailored specifically to organizations that use modern e-business technologies.

2.2. Adaptive e-Business Continuity Management

As previously stated, the proposed framework for adaptive e-Business continuity management was initially introduced in [9]. It was defined with reference to the ISO 22301 standard[8], which is the de facto primary international standard for business continuity management, following the systematic collection, review, and analysis of business continuity literature and existing frameworks. At later stages of our research, the framework was implemented in three organizations from the financial sector.

The framework combines parameters with responses of an organization. The parameters reflect the basic characteristics of the business environment in which the host organization operates[8], [33], [34], as well as the main characteristics of the underlying technologies: ubiquity, global reach, universal standards, richness, interactivity, information density, personalization/customization, and the usage of social networks [35]. The framework parameters are the following: P1) BCMS objectives, P2) BCMS scope, P3) Specific context of the organization, P4) Threats, P5) Vulnerabilities, P6) Disruption timescale, P7) Financial impact, P8) Operational impact, P9) Processes' criticality levels, P10) Resource Financial Categories, P11) Risk appetite, and P12) Risk Priority Levels.

In accordance with ISO 22301, the response of an organization draws on business continuity management system, whose key elements are defined by four framework components: Business Impact Analysis (C1), e-BCM Risk Assessment (C2), Business Continuity Plan (C3); and Continual BCMS Improvement (C4). Figure 1 illustrates the components of the framework and their most important interdependencies. The organization's response is precisely defined with a set of specific objectives and procedures.

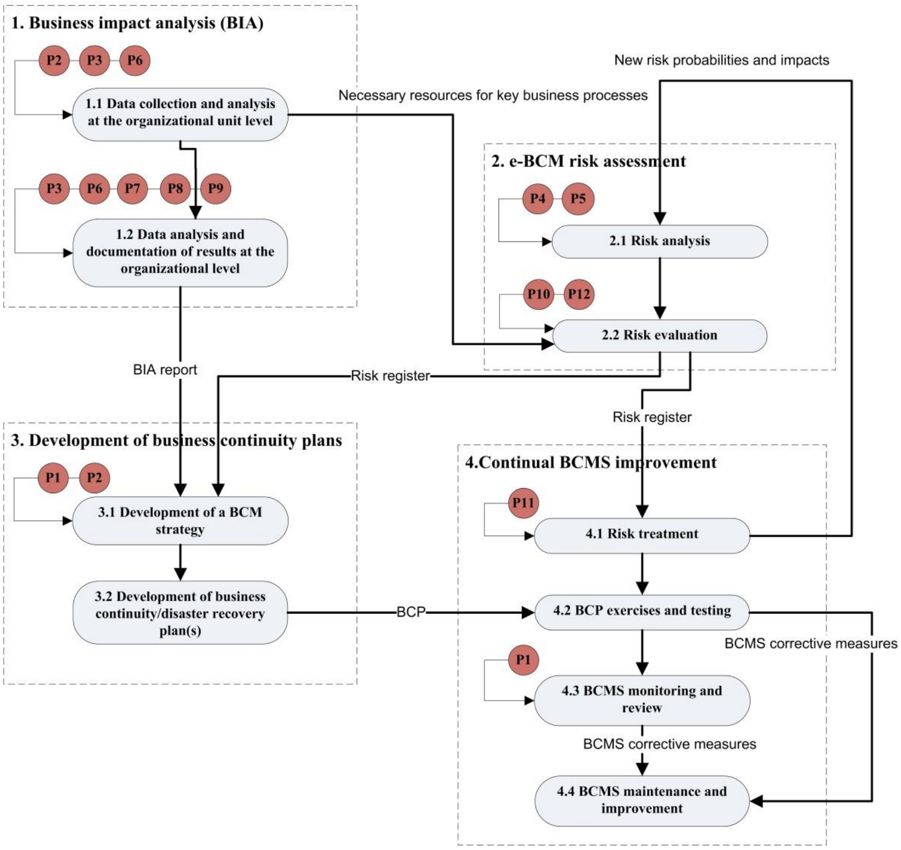

Fig. 1. The framework (parameters in circles; components in dotted-line rectangles; procedures, as part of components, in rounded-corner rectangles) and important interdependencies

Component number one deals with Business Impact Analyses (BIA). Its main objective is to identify the key business processes of the organization, as well as to determine how quickly these processes must recover and begin to provide complete business functions following an incident. This analysis draws on an assessment of potential financial, operational, regulatory, reputational, and other losses. Using parameter P7, organizations define whether the financial impact on the business will be evaluated, whereas parameter P8 defines all operational impacts that are assessed. Additionally, BIA further identifies the resources necessary for key business processes, and prioritizes recovery activities. As a result, data collection and analysis is performed first at the level of organizational units (procedure 1.1 within this component, see Figure 1). The analysis is performed only on business processes included in the BCMS (P2), and it key stakeholders and legal and regulatory framework of the organization (P3) are taken into consideration. Potential outcomes of disruption are analyzed based on a predefined disruption timescale (e.g., minutes, hours, days), in accordance with the nature of the business (P6).

Results are later analyzed and documented at the organizational level (procedure 1.2, see Figure 1). Criticality levels are identified for all processes based on their maximum acceptable outage (MAO) values (as defined by parameter P9).

The second component deals with e-BCM Risk Assessment, and consists of two procedures: risk analysis (2.1 in Figure 1), and risk evaluation (2.2 in Figure 1). Risk analysis identifies potentially achievable threats (P4) based on the present vulnerabilities of key business processes (P5). Risk evaluation involves assessing risk probabilities and impacts on the resources necessary for the key business processes, and results in calculating the risk values. Important input parameters for risk evaluation are Resource Financial Categories (P10) and Risk Priority Levels (P12). Resource Financial Categories (very high, high, medium, and low) are based on financial values, and are defined specifically for that organization. Risks are further categorized into four priority levels (very high, high, medium, and low) based on risk values, as defined by parameter P12.

The third component deals with the Business Continuity Plan (BCP). Its main goal is to define recovery procedures for key business processes within recovery time objectives, as determined under the BIA. A BCP can comprise one or multiple documents (sub-plans), depending on the geographical, organizational, and other business specifics of an organization. An important aspect of BCP is the recovery of critical information systems and ICT resources, which is often referred to as the Disaster Recovery Plan (DRP). This component consists of two procedures: the Development of a Business Continuity Strategy (3.1 in Figure 1) and the Development of Business Continuity/Disaster Recovery Plans (3.2 in Figure 1). The strategy reflects BCMS objectives (P1), and BCMS scope (P2), and should be based on the results of BIA analyses and risk assessments. It defines prerequisites, and provides all the necessary resources to be made available in case of a crisis situation.

The first three framework components define the most important elements of BCMS. Lastly, the final component deals with continual BCMS improvement. It considers internal and external changes within the organization’s environment, and defines corrective measures for the improvement of the BCMS. This component consists of procedures for risk treatment, business continuity plans exercises and testing, monitoring, review, maintenance, and improvement of BCMS. The risk appetite of an organization (P11) is an important parameter for risk treatment (procedure 4.1, Figure 1). Only risks with values above the defined threshold are mitigated. BCP exercises and tests (procedure 4.2, Figure 1) are used to validate BCP content, and to ensure that response and recovery results can be achieved within the defined timeframes [9]. BCMS monitoring and review (procedure 4.3, Figure 1) includes the evaluation of BCMS performance against defined BCMS objectives (P1). Finally, BCMS maintenance and improvement (procedure 4.4, Figure 1) implements pre-defined corrective measures designed to improve the BCMS. The main objective of this component is to provide an adaptive business continuity management.

For the proposed framework, this research has been focused on the following main research questions: 1) The framework defines clear and effective procedures for the establishment of e-business continuity management; 2) The framework examines the specifics of an organization's business, particularly its use of modern e-business technologies; 3) The framework facilitates the establishment of business continuity in an organization that uses modern e-business technologies; 4) The framework enables adaptive e-BCM in accordance with changes to the organization's environment, and 5) The framework contributes to a positive organizational attitude towards e-BCM. We refer to all these research questions as the core of an Adaptive e-BCM.

In the next chapter, we present the evaluation of the described framework.

3. Research Methods

3.1. Research Context

As stated previously, the proposed framework has been implemented in three organizations active in the financial sector in Serbia (see Table 2). The first implementation was in the Association of Serbian Insurers, a regulatory organization for insurance companies handling the Motor Third-Party Liability (MTPL) insurance in Serbia. The implementation took place in 2013, and the project lasted three months. Since the Association of Serbian Insurers is responsible for the centralized information system for the sale of MTPL policies interviews were conducted with all insurance companies in Serbia during the BIA analysis. The second implementation was a year later, in Milenijum Osiguranje, an insurance company with 300 employees that provides all types of non-life insurance. This project lasted four months. The last implementation was in 2015 and 2016, in the National bank of Serbia (NBS). The project lasted seven months, and included the involvement of over 200 NBS employees at some point. The top management support was critical for the project's success.

All three organizations that implemented the framework agreed to take part in the framework evaluation. However, due to confidentiality reasons, we were explicitly asked not to publish separate evaluation results, but rather to consider all three organizations as a single evaluation sample.

3.2. Evaluation Hypotheses

The main goal of the evaluation is to assess how effective the framework is at establishing adaptive e-BCM. Evaluation hypotheses are based on the theoretical background and assessment of interdependencies between the components.

The first set of evaluation hypotheses tests whether each framework component is instrumental for the establishment of adaptive e-BCM, and how significant its contributions are:

H1a: The Business Impact Analysis component (C1) contributes to the establishment of an adaptive e-BCM.

H1b: The e-BCM risk assessment component (C2) contributes to the establishment of an adaptive e-BCM.

H1c: The component for the development of Business Continuity Plan (C3) contributes to the establishment of an adaptive e-BCM.

H1d: The component encompassing continual BCMS improvement (C4) contributes to the establishment of an adaptive e-BCM.

The second set of evaluation hypotheses pertains to the Business Impact Analysis component (C1). One of the main objectives of BIA analysis is to identify key business processes of an organization and its necessary resources, which is a starting point for risk assessment. The following evaluation hypothesis is, therefore, proposed:

H2a: Implementation of the Business Impact Analysis component (C1) contributes to the implementation of an e-BCM risk assessment component (C2).

Recovery time objectives for key business processes are determined with reference to the results of BIA analysis. These are the Recovery Point Objective (RPO), Recovery Time Objective (RTO), and Maximum Acceptable Outage (MAO). The recovery time objectives define boundaries within which key business process must recover, and constitute the main goals of BCM, as well as a starting point for the development of the Business Continuity Plan document. Hence, the following evaluation hypothesis is derived:

H2b: Implementation of the Business Impact Analysis component (C1) contributes to the implementation of the component for the development of the Business Continuity Plan (C3).

The next set of evaluation hypotheses concerns the e-BCM Risk Assessment component (C2), which is focused on all risks that can lead to the interruption of business processes, and not just security incidents. To account for this fact, the impact parameters (P4 and P5) include predefined lists of potential threats and vulnerabilities for the organization. The potential threats and vulnerabilities are focused on information systems and usage of modern e-business technologies. So defined, risk assessment makes an important contribution to strategic and operational decision-making in the organization [36]. The following evaluation hypothesis is therefore proposed:

H3a: Implementation of the e-BCM risk assessment component (C2) contributes to the implementation of the component for the development of the Business Continuity Plan (C3).

The results of risk assessment inform the treatment of all risks above a certain acceptability level, as identified through the Risk Appetite parameter (P11). The purpose of risk treatment is to take preventive action to address the causes and impacts of potential risk events. Risk treatment is an integral part of the Component for continual BCMS improvement (C4); the following hypothesis is, therefore, proposed:

H3b: Implementation of the e-BCM risk assessment component (C2) contributes to the implementation of the component for continual BCMS improvement (C4).

The component for continual BCMS improvement (C4) is applied at planned intervals and after each important change in the organization's environment. Procedures that are part of this component include BCP exercises and tests. Short of an actual disruptive incident, BCP exercises and tests are the only means of validating BCP content and ensuring that response and recovery results can be achieved within defined timeframes. Therefore, the final evaluation hypothesis is:

H4: Implementation of the component for continual BCMS improvement (C4) contributes to the component for the development of Business Continuity Plan (C3).

All evaluation hypotheses are presented in Figure 2, while Table 1 gives an overview of the literature used.

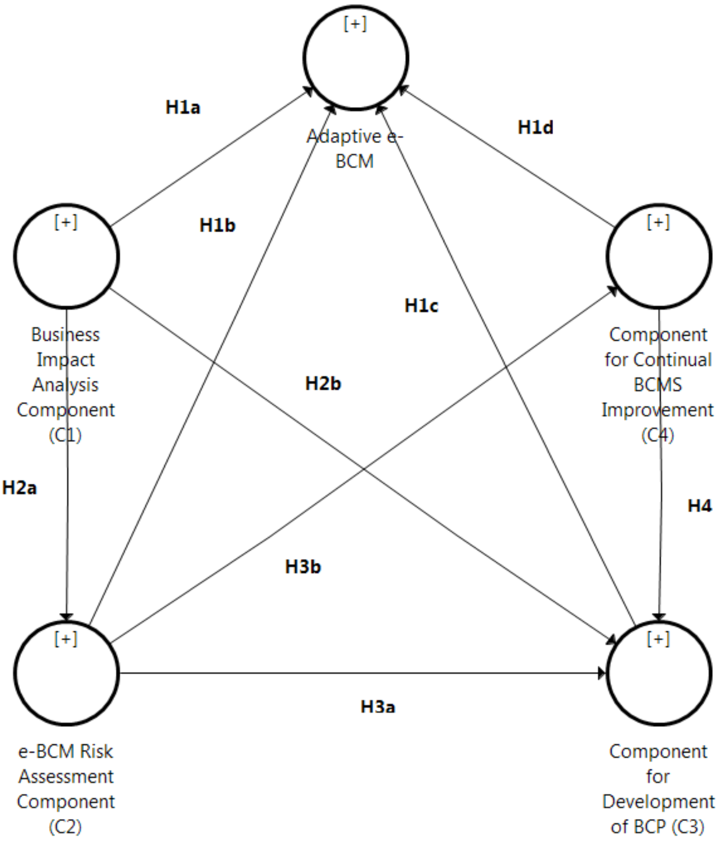

Fig. 2. Evaluation hypotheses (the structural PLS-SEM model)

Table 1. Evaluation hypotheses and theoretical background

Hypothesis	Theoretical background
H1a: C1 -> Adaptive e-BCM H1b: C2 -> Adaptive e-BCM H1c: C1 -> Adaptive e-BCM H1d: C2 -> Adaptive e-BCM	Each framework component is instrumental for the establishment of adaptive e-BCM[9]

H2a: C1 -> C2	Key business processes are identified in BIA analyses[34], [37]; risk assessment is performed on the resources necessary for the key business processes[9], [29], [38]
H2b: C1 -> C3	Recovery time objectives for key business processes are based on the results of BIA analysis[8], [22], [34], [39]
H3a: C2 -> C3	Business Continuity Plan should be based on results of BIA analysis and risk assessment[8], [22], [34]; results of risk assessment are important for strategic and operational decision-making in the organization[36]
H3b: C2 -> C4	Risk treatment is based on the results of risk assessment[8], [29], [38]
H4: C4 -> C3	BCP exercises and tests are essential part of effective business continuity management[8], [34]

3.3. Evaluation Questionnaire and Data Collection

To evaluate the proposed framework and to test evaluation hypotheses, we constructed an evaluation questionnaire (survey) containing a set of evaluation questions (survey items); this questionnaire is provided in Appendix A. All responses were made on a 5-point Likert scale, with the categories being (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree.

Table 2. Organizations that implemented the framework and took part in the evaluation

Organization	No. of employees	Project duration	No. of key business processes	No. of key users who participated in the evaluation
1. Association of Serbian Insurers	20	3 months	8	3
2. Milenijum Osiguranje Insurance Company	300	4 months	31	9
3. National Bank of Serbia	2,000	7 months	115	26
Total no. of evaluations:				38

Survey items used to evaluate the Adaptive e-BCM were based on the key research questions as defined in[9], and discussed in the previous chapter. They were defined in accordance with the international standard[8] and BCMS performance evaluation[40]. In addition, some survey items were based on the following literature:[34], [39], [41] for evaluating the Business Impact Analysis component (C1);[13], [36], [38] for evaluating the e-BCM risk assessment component (C2);[41]–[43] for evaluating the component for development of Business Continuity Plan (C3); and[44] for evaluating the component for continual BCMS improvement (C4).

Key users from three organizations that implemented the framework took part in the evaluation (see Table 2 for details). All three organizations are from the financial sector in Serbia, and they are all subject to the same standards and rules regarding business continuity. As already stated, due to confidentiality reasons, all three organizations were considered as a single sample. The evaluation was performed between April and June 2017.

3.4. Evaluation Methodology

The evaluation was performed in three steps, as presented in Table 3. Basic statistical analysis, together with statistical significance test (Step 1), was used to determine whether the main research questions hold, and to assess framework effectiveness. A more thorough analysis of the findings of the evaluation (Steps 2 and 3) was conducted using Structural Equation Modeling (SEM), an advanced statistical analysis technique that can identify relationships among measured variables and latent variables (variables that are not directly measured), as well as between latent variables[45]. In our research, we used Partial Least Squares SEM (PLS-SEM), which is a good alternative to Covariance-Based SEM (CB-SEM) for estimating theoretically justified cause-effect relationships in models, especially at small sample sizes[46], [47]. PLS-SEM works efficiently with small sample sizes and generally makes no assumptions about data distributions. We used SmartPLS software (v.3.2.7) for analysis[48].

Table 3. Evaluation Steps

Evaluation step		Evaluation method	Purpose of the evaluation step
1.	Evaluation of framework effectiveness	Basic statistical analyses and statistical significance test	Determine whether main research questions hold and whether the framework is effective in implementation
2.	Evaluation of the measurement model (outer model)	PLS-SEM standard algorithm	Assess the reliability and validity of the evaluation questionnaire
3.	Evaluation of the structural model (inner model)	PLS-SEM blindfolding and bootstrapping	Test evaluation hypotheses

The PLS-SEM analysis consists of the evaluation of corresponding PLS-SEM structural and measurement models.

The structural model (also called the inner model in PLS-SEM) illustrates the research hypotheses and displays the variable relationships that will be examined [45]. We have created the structural model based on our evaluation hypotheses (see Figure 2). In PLS-SEM, variables that are not directly measured are called constructs, and they are represented in models as circles or ovals. The indicators, also called items or manifest variables, are the directly measured variables that contain the raw data, and they are represented in models as rectangles [45].

The measurement model (also referred to as the outer model in PLS-SEM) of the constructs displays the relationships between the constructs and the indicator variables[45]. The measurement model was defined with the survey items explained earlier in this chapter, and is described in more detail in Chapter 4.2 (see Figure 3).

The PLS-SEM models cannot be evaluated with a single goodness-of-fit criterion. Following PLS-SEM guidelines[45], [49]–[53], the study performed a two-stage approach to evaluation, as described in evaluation Steps 2 and 3 (see Table 3).

The following Chapter presents each of the tree evaluation steps in more detail.

4. Research Results

4.1. Evaluation of Framework Effectiveness

In the first evaluation step, a simple statistical analysis was performed based on mean values, standard errors, and standard deviation of all evaluation items. We set the mean value of 4 as the benchmark against which evaluation results may be compared. The basic assumption here was that the mean value of 4 is considered effective in implementing an adaptive e-BCM.

The first part of the questionnaire (items Q.1.1 – Q.1.5) refers to the core of an Adaptive e-BCM. Basic statistical analysis shows that evaluation results support the effectiveness of the core since the average score for each evaluation item is greater than 4 (see "Mean values for Part 1: Adaptive e-BCP" in Appendix A).

The other four parts of the questionnaire address the remaining issues of effectiveness, with questions grouped by framework components. The component for continual BCMS improvement (C4) received the lowest average score, 3.36, as it includes the most advanced activities from the business continuity maturity perspective, and its successful implementation requires some time. Other framework components received average scores greater than or very close to 4: 4.58 for the Business Impact Analysis component (C1), 4.05 for the e-BCM Risk Assessment component (C2), and 3.98 for the component for development of BCP (C3), which suggests that three out of four framework components are effective in implementing an adaptive e-BCM.

To further validate those claims, we have performed the statistical significance test (t-test) on the mean values for each evaluation item (please see Appendix A for details). We have used one-sample t-test with a 95% confidence level in software Stata (v.13). The null hypothesis was: Mean value is equal to 4 (H0: Mean=4). For each evaluation item we computed test of statistical significance for other alternative hypotheses: Mean value is lower than 4 (Ha: Mean<4), Mean value is not equal to 4 (Ha: Mean!=4) and Mean values is greater than 4 (Ha: Mean>4), where the last one is the most relevant for our research. As presented in Appendix A, four out of five items in Part 1: Adaptive e-BCP passed the t-test in the sense that the probability to reject the null hypothesis against the alternative (Ha: Mean>4) is below the significance level of 5%. Only item Q.1.5: "The framework contributes to a positive organizational attitude towards e-BCM" didn't pass the statistical significance test.

For Business Impact Analysis Component (C1), all evaluation items passed the t-test, which shows that this component is, out of all four components, the most effective in implementation. The second two components partly passed the t-test: two out of six evaluation items for e-BCM Risk Assessment Component (C2), and three out of six items for Component for Development of Business Continuity Plan (C3). These results implicate that those components need further adjustments, especially in the areas of continual improvements, to achieve full effectiveness in practice. For similar reasons, the Component for Continual BCMS Improvement (C4) didn't pass the statistical significance test. Business continuity is an ongoing process[8], and our opinion is that this component needs years of continual practice to achieve the desired level of effectiveness.

4.2. Evaluation of the Measurement Model

After the basic statistical analyses of the findings, we have conducted a more thorough analysis with PLS-SEM. The first part was an evaluation of the PLS-SEM measurement model. Our measurement model (Figure 3) is reflective: each of its measures (items, indicators) represents the effects (or manifestations) of an underlying construct[45]. All constructs have multi-item measures. We evaluated the reliability and validity of the construct's measures by examining PLS-SEM estimates. The results are reported in Figure 3 and Table 4.

Firstly, we assessed internal consistency reliability, i.e., whether the proposed indicators are valid measures of the construct. As argued by [45], the appropriate measure of internal consistency reliability is composite reliability which, compared to alternative measure - Cronbach's alpha, takes into consideration the varying outer loading of the indicator itself and not only the intercorrelations of the observed indicator variables. Table 4 reveals that composite reliability values for all constructs stand at between 0.80 and 0.95, demonstrating high internal consistency reliability[45], [50], [53].

Table 4. Summary of Results for Reflective Outer Model

Constructs	Composite Reliability	AVE
Adaptive e-BCM	0.854	0.545
Business Impact Analysis Component (C1)	0.808	0.518
e-BCM Risk Assessment Component (C2)	0.915	0.687
Component for Development of BCP (C3)	0.880	0.648
Component for Continual BCMS Improvement (C4)	0.933	0.737

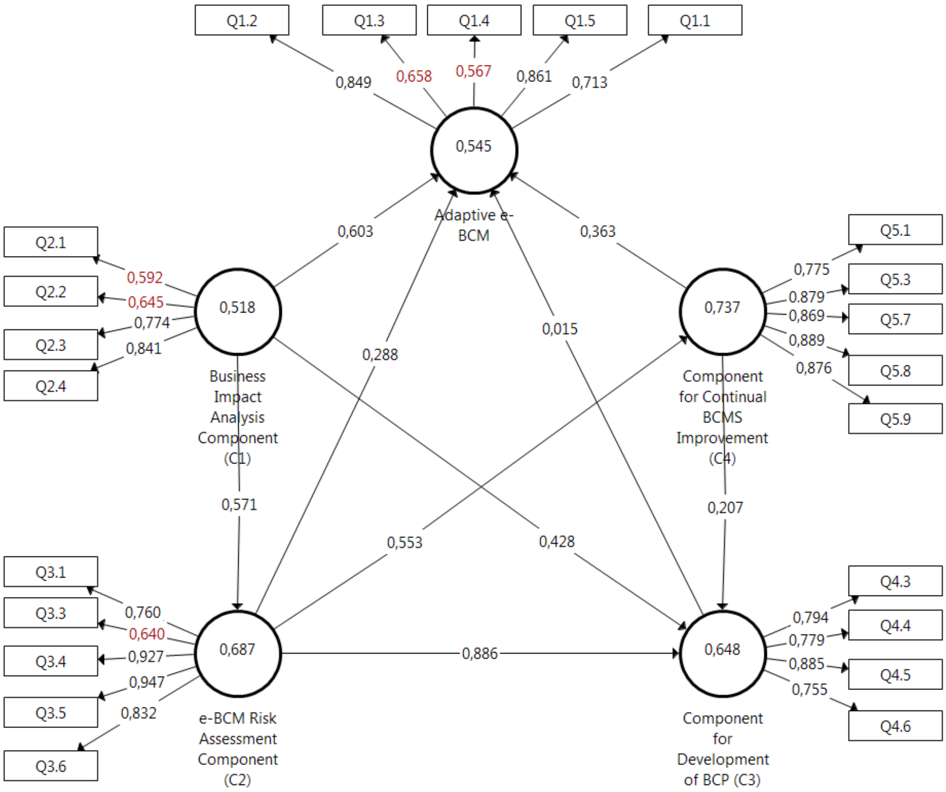

Fig. 3. PLS algorithm results (Inner model: Total Effects, Outer model: Outer Loadings, Constructs: Average Variance Extracted - AVE)

Next, we examined whether convergent validity was established, by measuring the outer loadings of the indicators (also called indicator reliability) and the Average Variance Extracted (AVE) of the constructs[45].

Indicators associated with a construct with high outer loadings have much in common, which is captured by the construct. Out of an initial set of indicators (listed in Appendix A), twelve indicators with outer loadings of between 0.40 and 0.70 were considered for removal from the model, as suggested in[45], by examining whether deleting the indicator would lead to an increase in the composite reliability or AVE above the preferred thresholds. Based on those criteria, six items (Q2.5, Q2.6, Q3.2, Q4.1, Q4.2, and Q5.6) were not included in further analysis. For example, a clear majority of the respondents “strongly agreed” with items “Q2.5 Recovery time objectives are determined.” and “Q4.1 BCMS is adequately defined”.

In addition, three indicators with excessive outer loading values (of around 0.95) were also removed from the model (Q5.2, Q5.4, and Q5.5), as suggested by [45], so that consistency reliability of the corresponding construct could remain below an upper threshold of 0.95.

All the items removed were carefully examined so as not to have major effects on the corresponding construct’s content validity as suggested in[45]. Figure 3 shows that all remaining indicators have outer loadings above the preferred level of 0.708 or very close to it (sufficiently close values are marked in red).

The results indicated (see Table. 3) that all construct AVE values were greater than the acceptable threshold of 0.5 suggested by [45], which means that the construct, on average, explains more than half of the variance of its indicators.

Lastly, we examined discriminant validity, that is, the extent to which a construct is truly distinct from other constructs by empirical standards. As argued by [45], there are two measures of discriminant validity: cross loadings of indicators, considered a liberal approach[54], and the Fornell-Larcker criterion, a more conservative approach [55]. Discriminant validity was established for all constructs according to the first method, which means that their outer loading on associated constructs are greater than all of their loadings on other constructs for all indicators (that is why this method is called "cross loadings"). Application of the second method, as shown in Table 5, revealed only one minor discrepancy between the e-BCM Risk Assessment Component (C2) and the Component for Development of BCP (C3). Since the correlation between those two variables is only slightly greater than the square root of AVE (approximately 0.037), we considered this acceptable.

Table 5. Discriminant Validity: Fornell-Larcker Criterion

Construct	C1	Adaptive e-BCM	C4	C3	C2
Business Impact Analysis Component (C1)	0.720				
Adaptive e-BCM	0.619	0.738			
Component for Continual BCMS Improvement (C4)	0.359	0.569	0.859		
Component for Development of BCP (C3)	0.437	0.489	0.606	0.805	
e-BCM Risk Assessment Component (C2)	0.571	0.538	0.553	0.841	0.829

4.3. Evaluation of the Structural Model and Hypotheses Testing

As the measurement characteristics of the constructs were proven to be acceptable, we continued with the assessment of the PLS-SEM structural model. The following assessments were conducted:

- Collinearity among sets of constructs;
- Model's predictive accuracy;
- Model's predictive validity; and
- Structural model relationships.

The variance inflation factor (VIF) is a measure of collinearity. In our structural model, all VIF values are below 5, which indicates that there are no collinearity issues among sets of constructs[45].

The coefficient of determination (R^2), as a measure of the model's predictive accuracy, was measured only for endogenous latent variables: Adaptive e-BCP (R^2 =

0.525), C2 (R^2 = 0.326), C3 (R^2 = 0.741) and C4 (R^2 = 0.305). The R^2 value for C3 is considered substantial, whereas R^2 values for other endogenous latent variables (Adaptive e-BCP, C2, and C4) are considered moderate [56].

The cross-validated redundancy measure of Q^2 was used to assess the model's predictive validity [57], [58]. Running the blindfolding procedure with an omission distance of seven yielded a Q^2 value of 0.427 for C3, which indicates a large predictive relevance [45]. Other endogenous latent variables have medium predictive relevance: Adaptive e-BCP (Q^2 = 0.227), C2 (Q^2 = 0.187), and C4 (Q^2 = 0.175).

Structural model relationships were assessed using structural model path coefficients, which were obtained after running the PLS-SEM algorithm (see Figure 3). Whether a coefficient is significant ultimately depends on its standard error, which is obtained by means of bootstrapping. The bootstrap standard error allows computing the empirical t value. When the empirical t value is larger than the critical value, we say that the coefficient is significant at a certain error probability (i.e., significance level). The critical value for two tailed tests was 1.96 for a significance level of 5% [45].

The study assessed the structural model through complete bootstrapping with 5,000 samples (significance level 5%, two-tailed test, individual sign changes option). Results are shown in Figure 4 and Table 6.

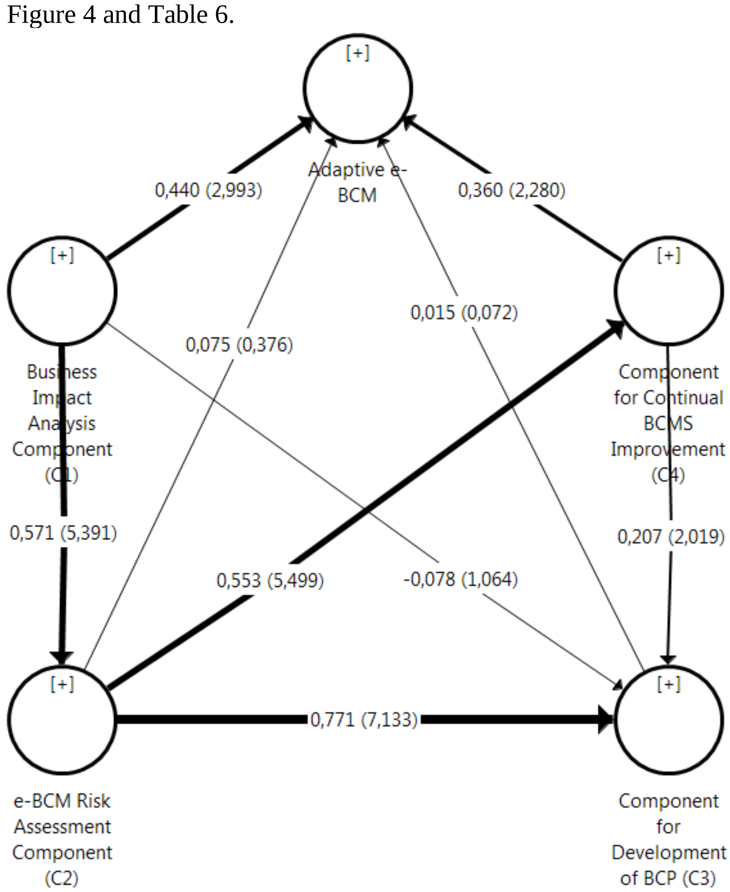

Fig. 4. Bootstrapping Results (Inner model: Path Coefficients and T-Values)

Table 6. Bootstrapping Results

Hypothesis	Original Sample	Sample Mean	Standard Deviation	T Statistics
H1a: C1 -> Adaptive e-BCM	0.440	0.468	0.147	2.993***
H1b: C2 -> Adaptive e-BCM	0.075	0.255	0.200	0.376
H1c: C3 -> Adaptive e-BCM	0.015	0.287	0.214	0.072
H1d: C4 -> Adaptive e-BCM	0.360	0.307	0.158	2.280***
H2a: C1 -> C2	0.571	0.598	0.106	5.391***
H2b: C1 -> C3	-0.078	-0.108	0.073	1.064
H3a: C2 -> C3	0.771	0.770	0.108	7.133***
H3b: C2 -> C4	0.553	0.565	0.100	5.499***
H4: C4 -> C3	0.207	0.207	0.103	2.019***
*** T>1.96 (significance level 5%)				

The results revealed a positive and significant effect of the Business Impact Analysis Component (C1) and the Component for Continual BCMS Improvement (C4) on the Adaptive e-BCP, but no significant direct effect of the e-BCM Risk Assessment Component (C2) or the Component for Development of BCP (C3). C1 has the strongest effect on the Adaptive e-BCP ($\beta = 0.440$, $T > 1.96$), followed by C4 ($\beta = 0.360$, $T > 1.96$). Therefore, hypotheses H1a, and H1d hold. The relationship between the e-BCM Risk Assessment Component (C2) and the Adaptive e-BCM is not significant ($\beta = 0.075$ $T < 1.96$), so H1b does not hold. Similarly, the relationship between the Component for Development of BCP (C3) and the Adaptive e-BCM is not significant ($\beta = 0.115$, $T < 1.96$), so H1c does not hold either.

The Business Impact Analysis Component (C1) has a very significant effect ($\beta = 0.571$, $T > 1.96$) on the e-BCM Risk Assessment Component (C2), so hypothesis H2a holds. On the other hand, C1 does not have a significant effect on C3 ($\beta = -0.078$, $T < 1.96$) and, therefore, hypothesis H2b does not hold.

The e-BCM Risk Assessment Component (C2) has a very significant effect on both C3 ($\beta = 0.771$, $T > 1.96$) and C4 ($\beta = 0.553$, $T > 1.96$), so hypotheses H3a and H3b both hold.

Finally, the relationship between the Component for Continual BCMS Improvement (C4) and the Component for Development of BCP (C3) is significant ($\beta = 0.207$, $T > 1.96$), so hypothesis H4 holds.

5. Discussion

Basic statistical analysis reveals that the main research questions hold, and that Business Impact Analysis Component (C1) is the most effective in practice, whereas the other three framework components need some additional adjustments to achieve the desired level of effectiveness.

Evaluation hypotheses tested in the PLS-SEM analysis can be divided into two distinct groups: one that examines direct contributions of framework to the establishment of adaptive e-BCM (H1a, H1b, H1c, H1d) and the other that examines the framework's internal structure, that is, the interdependencies between the components (H2a, H2b, H3a, H3b, H4).

The adaptive e-BCP, which represents the main research questions, reveals the framework' effectiveness at establishing adaptive e-BCM. The results show that the Business Impact Analysis Component (C1) and the Component for Continual BCMS Improvement (C4) have a positive and significant effect on the implementation of Adaptive e-BCP. For the other two components, the e-BCM Risk Assessment Component (C2), and the Component for Development of BCP (C3), results of PLS-SEM analysis didn't show direct significant effects. This means that, in the proposed framework, BIA analysis and continual BCMS improvements are the factors primarily responsible for the effective establishment of adaptive e-BCM. On the other hand, evaluation results show that component for e-BCM Risk Assessment (C2) has an indirect effect on the Adaptive e-BCM, through the Component for Continual BCMS Improvement (C4), since results of risk assessment are the basis for risk treatment.

The framework shows high internal consistency and logical structure, as all evaluation hypotheses in the second group hold, except for H2b: Implementation of the Business Impact Analysis component (C1) contributes to the implementation of the component for the development of Business Continuity Plan (C3).

The Business Continuity Plan (BCP) is a documented set of procedures that guides an organization to respond, recover, resume, and restore a pre-defined level of operation following a disruptive incident [8]. A BCP ensures that business processes recover rapidly and effectively, that damage to the business is minimized, and that business disruption is managed [17]. It defines the resumption of an organization's key business processes within recovery time objectives, as defined in the BIA[39]. Therefore, the significant direct effect of the Business Impact Analysis Component (C1) on the Component for Development of BCP (C3) is only to be expected. This hypothesis did not hold in our evaluation, which suggests that further improvements should be made to the framework to enhance the connection between these two components. By contrast, the Business Impact Analysis Component (C1) has an indirect impact on the Component for Development of Business Continuity Plan (C3) through the e-BCM Risk Assessment Component (C2), so minor framework adjustments are needed.

Having closely examined all aspects, we concluded that an additional framework parameter should be added, that of Recovery time objectives (P13). Recovery time objectives of key business processes, as defined in BIA, are crucial business continuity objectives that must be addressed by the Business Continuity Plan [34]. This adjustment will define the important relationship between the Business Impact Analysis Component (C1) and the Component for Development of Business Continuity Plan (C3) more precisely.

Regardless of the suggested adjustments, the overall evaluation results are positive, and we can conclude that the framework is effective in establishing adaptive e-business continuity management.

The most relevant practical application of our research is that the proposed framework defines a general context for the establishment and continuous improvement of e-BCM, and is particularly tailored for organizations that use modern e-business technologies. It includes practical steps, grouped into procedures and components, for defining the most important elements of a business continuity management system: business impact analysis, risk assessment, and business continuity plan. In addition, it guides an organization through continual BCMS improvement which, as we have shown, is one of the main drivers for the effective establishment of adaptive e-BCM.

The small evaluation sample presents the main limitation of our research. However, we consider it as a blueprint for how evaluation should be conducted, once a bigger sample is gathered. We have addressed this limitation by selected PLS-SEM method for evaluation, which works efficiently with small sample sizes. The main threat to the validity of our research is that the proposed framework has only been implemented in organizations from the financial sector, whereas we argue that the framework is general and can be applied in any organization that uses modern e-business technologies. This threat was partly addressed with the implementation of the framework in the National bank of Serbia, within which operates The Institute for Manufacturing Banknotes and Coins as a separate business entity in the field of the graphics industry. Moreover, all three organizations which implemented the framework have the following characteristics common to all organizations that use modern e-business technologies: 1) use of e-services that are critical to business (e.g., online insurance sales, B2B e-services in NBS), 2) cloud IT infrastructure, 3) shared business processes between multiple organizational units, and 4) high standards in information security and data protection.

The framework should be applied every time there is a change in any of the framework parameters, which enables the e-BCM to flexibly respond to changes in the organization's business environment. Corrective BCMS measures are set out in the continual BCMS improvement [8], [34]. Adaptability to changes in the business environment of the organization, together with corrective BCMS measures, allows adaptive e-BCM.

6. Conclusions

Due to the rapid development of e-business technologies in an uncertain world, organizations and their information systems have tremendous risks in the face of potential disaster shocks. In response to that, they need to design adaptive e-Business Continuity Management. Our research is focused on improving business continuity management in organizations that use modern e-business technologies, for which we have introduced the concept of "e-Business Continuity Management" (e-BCM). Our approach was to create a framework for adaptive e-Business continuity management that is sufficiently general and flexible in order to enable any organization to specify their own BCMS: BIA analysis, risk assessment, and business continuity plans. The framework was implemented in three financial organizations of various sizes.

The main contribution of this research paper is the evaluation of the proposed framework based on its application in real business practices. We have evaluated whether the proposed framework is effective in the implementation of adaptive e-Business continuity management in three financial organizations in Serbia. Using the PLS-SEM analysis, we have shown that two out of four framework components, BIA analysis, and continual BCMS improvement, have a statistically positive contribution to the effective establishment of adaptive e-BCM. For the contribution of the remaining two components of the framework, risk assessment and development of Business Continuity Plan, further development and analyses are needed.

Although the evaluation sample is small, we emphasize that one of the institutions that implemented the proposed framework is a central bank, with very complex and challenging specifics. That is why we consider evaluation results relevant, especially in circumstances where there is no similar research available in the open literature. We will continue this research by further developing the framework and implementing it in additional organizations, both financial institutions and those outside the financial industry. Additional implementations will be followed by further detailed evaluation of our approach, with the aim of proving that all framework components have an important contribution to the effective establishment of adaptive e-BCM.

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7. Appendix A

Table 7. Measurement items included in the questionnaire and indicators for reflective measurement of model constructs, with statistics

							The probability to reject the alternative hypothesis			
ID	Indicator	Mean	Std. Dev.	95% Conf. Interval		t value	Ha: Mean < 4	Ha: Mean != 4	Ha: Mean > 4	Outer Loadings
Part1: Adaptive e-BCM, Simple average 4.45										
Q1.1*	The framework defines clear and effective procedures for the establishment of e-business continuity management	4.500	0.647	4.287	4.713	t = 4.7621	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.707*
Q1.2*	The framework examines the specifics of an organization’s business, in particular its use of modern e-business technologies	4.500	0.647	4.287	4.713	t = 4.7621	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.85*
Q1.3*	The framework facilitates the establishment of business continuity in an organization that uses modern e-business technologies	4.684	0.620	4.481	4.888	t = 6.8058	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.665

Q1.4*	The framework enables adaptive e-BCM in accordance with changes to the organization’s environment	4.421	0.758	4.172	4.670	t = 3.4239	Pr(T < t) = 0.9992	Pr(T > t) = 0.0015	Pr(T > t) = 0.0008	0.565
Q1.5	The framework contributes to a positive organizational attitude towards e-BCM	4.132	1.119	3.764	4.499	t = 0.7248	Pr(T < t) = 0.7634	Pr(T > t) = 0.4732	Pr(T > t) = 0.2366	0.861*
Part 2: Business Impact Analysis Component (C1), Simple average 4.58										
Q2.1*	BIA is carried out as a part of the organization’s key management activities	4.737	0.724	4.499	4.975	t = 6.2780	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.559
Q2.2*	Key business processes and their interdependences are identified	4.711	0.515	4.541	4.880	t = 8.5037	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.600
Q2.3*	Resources necessary for key business processes are identified	4.474	0.762	4.223	4.724	t = 3.8329	Pr(T < t) = 0.9998	Pr(T > t) = 0.0005	Pr(T > t) = 0.0002	0.76*
Q2.4*	Financial and operational impacts are assessed	4.316	0.842	4.039	4.592	t = 2.3129	Pr(T < t) = 0.9868	Pr(T > t) = 0.0264	Pr(T > t) = 0.0132	0.787*
Q2.5*	Recovery time objectives are determined	4.605	0.638	4.395	4.815	t = 5.8446	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.516
Q2.6*	Criticality levels for key business processes and recovery priorities are determined	4.658	0.534	4.482	4.833	t = 7.5940	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.564

Part 3: e-BCM Risk Assessment Component (C2), Simple average 4.05										
Q3.1*	Business continuity risk assessment process is established	4.237	0.786	3.978	4.495	t = 1.8571	Pr(T < t) = 0.9644	Pr(T > t) = 0.0713	Pr(T > t) = 0.0356	0.765*
Q3.2*	Results of risk assessment are adequately documented	4.421	0.758	4.172	4.670	t = 3.4239	Pr(T < t) = 0.9992	Pr(T > t) = 0.0015	Pr(T > t) = 0.0008	0.549
Q3.3	Risk assessment is performed on a regular basis	3.868	1.018	3.534	4.203	t = -0.7968	Pr(T < t) = 0.2153	Pr(T > t) = 0.4307	Pr(T > t) = 0.7847	0.640
Q3.4	Risk treatment process is established	3.947	1.038	3.606	4.289	t = -0.3125	Pr(T < t) = 0.3782	Pr(T > t) = 0.7565	Pr(T > t) = 0.6218	0.915*
Q3.5	Risk treatment methods are adequate	3.921	1.194	3.529	4.314	t = -0.4075	Pr(T < t) = 0.3430	Pr(T > t) = 0.6860	Pr(T > t) = 0.6570	0.927*
Q3.6	Risk treatment plan is regularly monitored	3.921	0.969	3.602	4.240	t = -0.5021	Pr(T < t) = 0.3093	Pr(T > t) = 0.6186	Pr(T > t) = 0.6907	0.835*
Part 4: Component for Development of Business Continuity Plan (C3), Simple average 3.98										
Q4.1*	BCMS is adequately defined	4.579	0.683	4.354	4.803	t = 5.2248	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.461
Q4.2*	Business continuity strategy is based on BIA and risk assessment results	4.605	0.679	4.382	4.829	t = 5.4917	Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000	0.661
Q4.3	Business continuity strategy defines and provides all necessary resources in the event	4.158	1.027	3.820	4.496	t = 0.9474	Pr(T < t) = 0.8252	Pr(T > t) = 0.3496	Pr(T > t) = 0.1748	0.805*

	of a crisis situation									
Q4.4*	Business continuity plan is adequately defined	4.289	0.867	4.004	4.574	t = 2.0581	Pr(T < t) = 0.9767	Pr(T > t) = 0.0467	Pr(T > t) = 0.0233	0.838*
Q4.5	Business continuity plan training is adequate	3.211	1.255	2.798	3.623	t = -3.8765	Pr(T < t) = 0.0002	Pr(T > t) = 0.0004	Pr(T > t) = 0.9998	0.773*
Q4.6	Business continuity plan is regularly tested	3.053	1.314	2.621	3.485	t = -4.4441	Pr(T < t) = 0.0000	Pr(T > t) = 0.0001	Pr(T > t) = 1.0000	0.629
Part 5: Component for Continual BCMS Improvement (C4), Simple average 3.36										
Q5.1	BCMS performance evaluation metrics are established	3.447	0.950	3.135	3.760	t = -3.5858	Pr(T < t) = 0.0005	Pr(T > t) = 0.0010	Pr(T > t) = 0.9995	0.705*
Q5.2	BCMS performance is regularly evaluated	3.447	1.155	3.068	3.827	t = -2.9484	Pr(T < t) = 0.0028	Pr(T > t) = 0.0055	Pr(T > t) = 0.9972	0.942
Q5.3	Results of performance evaluation are adequately documented	3.316	1.093	2.956	3.675	t = -3.8585	Pr(T < t) = 0.0002	Pr(T > t) = 0.0004	Pr(T > t) = 0.9998	0.912*
Q5.4	Adequate BCMS management review is established	3.342	1.097	2.981	3.703	t = -3.6958	Pr(T < t) = 0.0004	Pr(T > t) = 0.0007	Pr(T > t) = 0.9996	0.959
Q5.5	BCMS management review is regularly conducted	3.342	1.122	2.973	3.711	t = -3.6156	Pr(T < t) = 0.0004	Pr(T > t) = 0.0009	Pr(T > t) = 0.9996	0.965
Q5.6	BCMS management review provides decision-making on implementation of corrective BCMS measures	3.447	1.032	3.108	3.787	t = -3.3015	Pr(T < t) = 0.0011	Pr(T > t) = 0.0021	Pr(T > t) = 0.9989	0.648

Q5.7	Corrective BCMS measures are adequately documented	3.447	0.978	3.126	3.769	t = -3.4830	Pr(T < t) = 0.0006	Pr(T > t) = 0.0013	Pr(T > t) = 0.9994	0.806*
Q5.8	BCMS Improvement Plan is comprehensive and up-to-date	3.184	0.955	2.870	3.498	t = -5.2685	Pr(T < t) = 0.0000	Pr(T > t) = 0.0000	Pr(T > t) = 1.0000	0.904*
Q5.9	Management is regularly informed of the status of corrective BCMS measures	3.263	0.950	2.951	3.575	t = -4.7830	Pr(T < t) = 0.0000	Pr(T > t) = 0.0000	Pr(T > t) = 1.0000	0.908*

ID*: indicators that passed the t-test, in the sense that probability to reject the null hypothesis H0 against the alternative (Ha: Mean>4) is below the significance level (5%)

Outer Loadings*: indicators with desirable levels of outer loadings