

INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

Scientific Journal

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THE CHALLENGES AND ISSUES ON THE UNIVERSITY OF ZAGREB DURING COVID-19 CRISIS

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ABSTRACT

In a very short period, the COVID-19 pandemic moved the process of education at all levels to the online environment. Although e-learning in university education in Croatia is not new, students and teachers of the University of Zagreb face new challenges that often call into question the quality of teaching. In order for online teaching to be successful, it is necessary to take into account the criteria related to the successful teaching and learning process and apply them in the online environment. Starting from the assumption that online teaching should meet most of the criteria of face-to-face teaching, we tested the satisfaction of students at the University of Zagreb with online teaching and the extent to which online teaching meets the criteria related to quality of face-to-face teaching. Based on the obtained results, we discuss the shortcomings of online teaching in relation to face-to-face teaching at the University of Zagreb.

KEY WORDS

online education, university teaching, quality of online learning, students' attitudes regarding online education

CLASSIFICATION

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INTRODUCTION

The COVID-19 pandemic affected Europe in early 2020 and forced all European countries to find new ways to work, communicate, collaborate, educate. The only solution to these new circumstances has been found in digital technologies. Digital technologies have suddenly become the only possible option for continuing normal life and work. The education system of the Republic of Croatia, as well as the education system of many other European countries, faced new and difficult challenges during the COVID-19 pandemic.

The teaching and learning process had to move to an online education system at all levels in a very short period. If we take into account all levels of education, this transition was perhaps the most painless for the higher education system in the Republic of Croatia, primarily because the social environment for the university student population was not a key factor for learning and progress as for e.g. children in primary school. The process of implementing e-learning at the University of Zagreb began in 2007 with the adoption of a document called the “E-learning Strategy” [1].

This document, among other things, emphasizes the need to improve the quality of university education through systematic introduction of e-learning and the need to provide support to lecturers and students in achieving new roles in e-learning. In addition to the aforementioned document, another document that indicates the systematic support and implementation of e-learning at the University of Zagreb is the “Strategy for studies and studying of the University of Zagreb” (2014-2025) [2] which emphasizes the importance of encouraging a number of activities related to e-learning – from the development of a virtual environment for learning and teaching, evaluation of e-courses, to the development of online studies.

However, despite all of the abovementioned preparations for working in the online environment in higher education, extensive research on the experiences and needs of higher education staff and students with regard to online teaching at faculties, conducted by the Agency for Science and Higher Education in 2020, showed that both staff and students still consider online teaching to be lower quality than face-to-face teaching. Agency for Science and Higher Education of the Republic of Croatia presented the results of the research in the report “Challenges in Higher Education during the COVID-19 Pandemic and Social Isolation”, and the results show that only 38 % of college teachers consider the quality of online lectures equal to face-to-face lectures. On the other hand, as many as half of the students (50 %) believe that the quality of online teaching performance is worse than the quality of teaching before the quarantine.

Such results are not surprising if we take into account that online teaching at higher education institutions in the Republic of Croatia, even in 2020, in terms of implementation, is in its infancy and a very small number of faculties, in fact, conduct online teaching as they prefer live teaching. The reasons for such attitude towards online teaching in Croatia are numerous, and they mainly stem from insufficient education of lecturers aimed at developing the culture of online education, unregulated need for continuing education and training of faculty at online education, and often insufficient material and technical conditions of faculties in the Republic of Croatia for conducting online teaching.

Considering the results of research on the quality of online teaching in higher education in the Republic of Croatia were not very good, two questions arise. The first question is whether something is being done wrong when it comes to online teaching, and the second question is whether a noticeable difference in quality between online and face-to-face education is really possible, if the ultimate goal of education is the learning process?

ONLINE DIDACTICS

Since online education was introduced to education system at all levels, especially higher education, scientists in various fields have been tackling the issue is there and should it be noticeable difference in quality between online and face-to-face education.

In this context, a great deal of research and meta-analyses have been done that prove that there are no significant differences between the two modes of education, online and face-to-face [3-6]. In other words, studies have confirmed that a well-prepared, structured and organized face-to-face lecture compared to an equally prepared online lecture results in equal acquisition of knowledge and skills development in students.

Considering the aforementioned studies' results, it is clear that the key to a successful teaching and learning process, regardless of the environment in which it is conducted, online or face-to-face, is a well-designed, well-prepared, organized and conducted lecture [7, 8]. In other words, the criteria for quality teaching are general and apply to both face-to-face teaching and online teaching. Thus, the guidelines for successful online teaching often emphasize the basic postulates of what is considered modern principles of face-to-face education, which arise from constructivist learning theories as a basic of modern teaching and learning, namely: learner-centred approach, emphasizing the importance of the active role of students in the process of constructing their own knowledge, emphasizing the need to initiate motivational processes and communication in the process of teaching and learning, encouraging deep learning and higher cognitive processes, emphasizing the importance of collaborative learning, quality system evaluations, etc. [9-12].

Despite the fact that online education includes basic pedagogical and didactical principles of contemporary teaching process, the fact that online education takes place entirely with the help of information and communication technology [13] should be taken into account. That fact, at least partially, requires new reflection on educational process considering that online environment inherently include certain specific principles which have affect the teaching and learning process. Therefore, it is necessary to take in consideration thinking about theory of online teaching and learning e.g. online didactics [14]. If we were to try defining what online didactics is, we could say it is a developing theory of teaching and learning process within online environment. It has not been written much about online didactics both in Croatia and abroad, but the current situation with COVID-19 emphasized the importance of online didactics and made us believe that the future will bring much more scientific and professional papers dealing with it. Despite the certain specific properties of online education, and those mostly refer to the factor of the newly created exclusive online environment within which process of teaching and learning takes place, the theory of online didactics in most of its part shares basic theoretical principles with traditional educational theories [15].

Everything mentioned above indicates that the successful application of the basic principles of contemporary teaching process, with which didactics deals, is the basis of quality teaching, whether it takes place in the classroom or online, and the key to successful online teaching is an online teacher [16] who should be able and also educated to follow constructivist learning theories and didactic principles of a successful teaching and learning process, regardless of the online environment.

RESEARCH OBJECTIVES

- 1.) To investigate the satisfaction of students at the University of Zagreb with online classes during the COVID-19 pandemic.
- 2.) To examine the factor structure of the questionnaire of attitudes towards online teaching.

METHODOLOGY

PARTICIPANTS

Participants in this study were students of the University of Zagreb whose undergraduate or graduate studies were Agronomy, Croatology, Fine Arts, Graphic Design, History, Mathematics, Philosophy, Psychology and Sociology. A total of 106 students participated in the study. Their age ranged from 20 to 24 years ($M = 22,2$). Seventy-five percent of the participants were female and twenty-five percent were male participants. The selection of participants was based on willingness to participate in the research. Sampling was non-probabilistic, carried out by the snowball method. This method of sampling limits the possibility of generalizing the results to other populations, but we believe that the research provides a good insight into the state of the examined constructs at the University of Zagreb, given that participants were students from different study groups who are guaranteed anonymity, so we assume that their answers were sincere and authentic.

INSTRUMENT AND PROCEDURE

The questionnaire used in this study was designed for study purposes in accordance with the theoretical assumptions about aspects of quality teaching. Participants assessed their opinions about quality of online teaching. Demographic items considered age, gender, college, study and study year. The questionnaire consisted of three parts. In the first part, questions were related to the platform that was used in online teaching, and general satisfaction with online teaching, how much students personally managed in online teaching and how well their professors managed. The second part included a series of questions that examine students' satisfaction with certain elements of quality teaching by categories, starting from the assumption that online teaching should meet the same criteria associated with classical teaching: stimulating classroom atmosphere and good teacher-student relations, structuring and planning the lesson, emphasizing learning goals and clarity of teaching, involvement and motivation of students, teaching metacognitive skills, higher order thinking, learning strategies and application of learning, individualization and differentiation of teaching for individual students and groups of students, formative evaluation and giving feedback on learning. The aim was to examine the satisfaction of students with online teaching in order to draw conclusions if online teaching, according to students, meets the criteria of classical teaching. In the third part of the questionnaire, participants were asked two open-ended questions: can they list the advantages of online teaching over classical teaching and what they have missed the most in online teaching. The survey was conducted with online questionnaires using Google Forms. Questionnaires were distributed to students via official e-mail addresses, Google Groups and social networks, with a request to forward the invitation to participate in the research to their colleagues. This article describes empirical results obtained by self-assessment.

RESULTS AND DISCUSSION

Descriptive statistics

Most of the participants, 76,4 % of them, reported that their college teachers used Merlin for online teaching purposes, which was expected considering that Merlin is the official E-learning platform of the University Computing Center of the University of Zagreb. However, as Merlin does not allow live video streaming of lectures, a large number of students reported using the Zoom, app. 61,3 % of them, and a smaller proportion of students, 10,4 % of them, stated that their college teachers used Skype. Slightly more than a third of students reported using Google Classroom (39,6 %) or Microsoft Teams (38,7 %). Occasionally, students listed

Google Docs (13,2 %) and course websites (6,6 %) in the “other” section, which was not listed as a category in the questionnaire itself because it was in some way implied, and can be classified as an older method not necessarily related to online teaching, but as an addition to the classic form of teaching.

The results show a relatively wide range of platforms and applications used with the purpose of achieving quality online teaching as each of these applications has its own unique advantages and capabilities.

Table 2 shows the answers to questions related to general satisfaction and activity in online teaching. It can be said that the participants rated online classes slightly higher than the middle grade ($M = 3,19$, $sd = 1,07$), they rated their college teachers slightly higher in the context of coping with online teaching ($M = 3,36$, $sd = 1,04$) and they assessed their ability to participate and perform obligations in distance learning with an average grade of $M = 3,82$ with $sd = 1,27$.

Table 1. The most commonly used platforms for online teaching (participants could mark multiple responses).

	N	percentage
Merlin	81	76,4
Zoom	65	61,3
Google Classroom	42	39,6
Microsoft Teams	41	38,7
Skype	11	10,4
Class web pages	7	6,6
Google Docs	14	13,2

Table 2. Level of satisfaction with online education in general.

	N	M	Sd
Satisfaction with online education process	106	3,19	1,07
How well did your teachers manage in online education?	106	3,36	1,04
How well did you manage to participate and fulfil the obligations in distance learning?	106	3,82	1,27
I was more active in online learning than in face-to-face learning	106	2,76	1,34

Factor structure and reliability of the questionnaire of attitudes about online education

In order to check the validity of the factor matrix calculation, we checked the Bartlett test of the significance of the correlation matrix, and the Kaiser-Meyer-Olkin sampling adequacy test. The Kaiser-Meyer-Olkin test was 0,84, which is a good value for factorization, and the Bartlett test showed the significance of the correlation matrix with a risk of less than 1 %. The structure of attitudes about online education was examined by the Principal component analysis. Based on the Kaiser-Guttman criterion, six factors with characteristic roots exceeding 1 were retained in the analysis. The factors obtained by the analysis of the principal components explain a total of 75,39 % of the variance of the manifest variables.

As shown in Table 3, the results of the factor analysis of assessment factors on the questionnaire of students' attitudes about online teaching. Six factors were extracted by the Principal component analysis, which together explain 75,39 % of the total variance. Based on the results of the factor analysis, six subscales were formed. Internal reliability is good: Cronbach's alpha for each subscale was: 1) $\alpha = 0,79$, 2) $\alpha = 0,85$, 3) $\alpha = 0,89$, 4) $\alpha = 0,89$, 5) $\alpha = 0,76$ and 6, $\alpha = 0,81$, and the average correlation between items $r = 0,69$.

Table 3. Review of the factor structure of the results on the questionnaire of students' attitudes about online education.

Factor	1	2	3	4	5	6
I was motivated for online teaching.	0,818	-0,215	0,025	0,079	-0,089	-0,172
I think the experience of online teaching will help me in the future.	0,701	0,045	-0,135	0,179	0,043	0,250
With the help of online teaching, I learn better.	0,726	-0,202	-0,276	-0,188	0,036	0,197
I communicate more successfully with the lecturer within the online / distance teaching.	-0,435	0,672	-0,025	0,200	0,069	0,151
Lecturers are more motivated to work in online teaching than in classical teaching.	-0,004	0,641	0,442	-0,124	0,073	0,183
The relationship between lecturers and students is much more open in online teaching.	-0,122	0,788	0,394	-0,035	0,125	0,193
The lecturers performed quality online classes.	0,442	0,025	0,731	-0,160	0,088	-0,185
Online lectures were clearly structured.	-0,076	0,252	0,770	0,050	-0,055	0,047
It was clear from the lecture what the students were expected to know.	0,157	0,260	0,776	-0,265	0,003	0,083
Students are encouraged to engage in discussions during online classes.	0,563	0,132	0,026	0,600	-0,152	0,202
The active role of students during online lectures is encouraged.	0,151	0,112	-0,023	0,634	0,123	0,155
Students are encouraged to participate in collaborative learning during online lectures.	0,029	-0,035	-0,139	0,700		-0,328
The lecturers tried to encourage the processes of reasoning, connecting, analyzing with their online lectures.	0,028	0,245	-0,226	-0,111	0,841	0,074
Lecturers used different teaching strategies in online teaching.	0,777	0,206	-0,165	-0,324	0,009	-0,104
The lecturers encouraged the learning process with their lectures during online classes.	0,800	0,069	-0,133	0,085	-0,105	-0,213
Lecturers gave feedback on time during online classes.	0,241	0,150	0,273	0,080	-0,023	0,733
The feedback was mostly encouraging.	0,326	0,129	0,156	0,023	-0,059	0,783
The way of evaluating knowledge was clearly explained.	0,195	0,333	0,203	-0,382	0,100	0,567

Items with which the first factor is highly saturated indicate the motivation of students for online learning. Examples of items: *I was motivated for online teaching; I think that the experience of online teaching will help me in the future.* The second factor includes the dimension of a stimulating classroom atmosphere and good teacher-student relations. Examples of items: *I communicate more successfully with a lecturer in online learning; Lecturers are more motivated to work in online teaching than in classical teaching.* The third factor includes claims related to structuring and planning lessons, emphasizing learning goals, and clarity of teaching. Examples of items: *Lectures online were clearly structured; It was clear from the lecture what the students were expected to know.* The fourth factor includes the dimension of teaching metacognitive skills, higher-order thinking, learning strategies, and applying what has been learned. Examples of items: *Students are encouraged*

to engage in discussions during online classes; Students are encouraged to participate in collaborative learning during online lectures. The fifth factor refers to the individualization and differentiation of teaching for individual students and groups of students, and examples are the following items: *Lecturers in online teaching used different teaching strategies; Lecturers in their online lectures tried to encourage the processes of reasoning, connecting, analyzing.* The sixth factor includes formative evaluation and giving feedback on learning, and examples are the following items: *Lecturers gave feedback on time during online classes; The way of evaluating knowledge is clearly explained.* Two particles saturated with multiple factors were excluded from further analysis: *Online lectures were mandatory* and *Exams should be easier given the quality of online teaching.*

Table 4. Results by factors / categories or aspects of quality of online education.

	N	Minimum	Maximum	Mean	Std. Deviation
Motivation	104	1,60	4,40	3,09	0,66
Teaching atmosphere	105	1,25	4,75	2,78	0,83
Planning	105	1,00	5,00	3,31	1,00
Student involvement in the education process	105	1,00	4,80	3,17	0,80
Individualization	104	1,29	4,43	3,06	0,75
Feedback	103	1,25	5,00	3,56	0,79
Valid N (listwise)	98				

The results of attitudes on certain aspects of the quality of online teaching show that students are relatively satisfied with the way their college teachers planned, structured and organized online teaching, opportunities for engagement during online teaching and feedback. They are somewhat less satisfied with the teaching atmosphere and the individualization of the teaching process, which is in line with expectations given that the very nature of online teaching reduces the possibility of these aspects of teaching. These results are important considering previous studies that showed that interaction in the classroom, student motivation, course structure, instructor knowledge, and facilitation were positively influencing students' perceived learning outcome and student satisfaction [17]. It was also found that perceived lecturers' feedback has a significant relationship with online learning students' satisfaction [18].

Future studies should examine personality traits and satisfaction with online teaching, especially in the context of the extraversion-introversion dimension. It is logical to assume that more introverted students will be more satisfied with online teaching. It is known that the teaching environment must not be adapted exclusively to one or the other, and that the teacher should not adapt the form of teaching to their preferences and characteristics [19]. From the answers of the participants to the question what they missed the most in online teaching, the level of frustration is visible, which is worrying in some answers, for example: *Normal social life, socializing with colleagues, interacting with professors, some of whom were great at online classes, and some didn't even bother to cope. I never want to hear about or experience online teaching again because it destroys the mental health of all of us.* On the other hand: *Due to the lack of lectures (I didn't have any lectures, only assignments and presentations) I had more time to study, and this was my best solved semester so far. I also gained more experience in writing papers.* Although some studies already pointed that users' personal factors have no direct influence on user satisfaction, while platform availability has the greatest influence on user satisfaction [20], further research is certainly needed to provide clear answers to these current questions.

In the participants' answers to open-ended questions, the emphasis was on the role of college teachers in the teaching process. When asked what they missed the most, most participants mentioned interaction with teachers, the possibility of asking questions directly and obtaining useful guidance in individual consultations. These findings indicate the importance and irreplaceability of the role of college teachers in the education process, even in the case of higher education, which implies a high degree of student independence and a developed ability to self-educate.

CONCLUSION

The results of the present study showed that most participants were satisfied with the online teaching process. The participants gave the highest grades to the aspects of structuring and planning the lessons, emphasizing learning goals, clarity of teaching and to their own engagement and motivation, and the lowest grades to the stimulating classroom atmosphere. The qualitative part of the research showed that participants differ in the degree of adjustment to online teaching in the sense that some participants prefer online teaching and some do not. However, the vast majority of participants' answers indicate the important role of the college teacher in the teaching process, whether it is classical or online teaching.

On one hand, study results indicate the need for additional education of college teachers that would go in the direction of encouraging a positive online classroom climate as a basic prerequisite for students getting comfortable with virtual learning.

The study also confirmed that successful application of didactic principles related to the teaching and learning process is the foundation of quality in face-to-face or online teaching. It also determined that the key to successful face-to-face as well as online teaching and learning actually is the teacher [13]. This study, like many other similar studies, confirmed that there are no differences between online and face-to-face teaching [3-6], as long as the emphasis is on a well-designed, well-prepared, organized and implemented teaching and learning process.

However, future studies need to involve not just students perspective but perspective of other subjects involved in online education such as college teachers, administration, college management etc.

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COMPARING RISK AND RESILIENCE APPROACHES

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ABSTRACT

Ever increasing challenges in the areas of risk management have led to a need for a risk management approach which deals not only with threat prevention but also adaption, absorption and recovery from adverse events. This has led to the rise of the concept of resilience analysis and management, which, unlike risk assessment and management focuses on the overall system under analysis rather than its individual components. Therefore, both the civilian and military sector have, over the past decade, emphasized the need to clarify the concept of resilience management as well as to differentiate it from related terms such as risk management. This article aims to build upon the existing literature and provide a comparison of the risk and resilience approaches which offer ways to analyse and manage these concepts.

KEY WORDS

risk assessment, risk management, resilience analysis, resilience management

CLASSIFICATION

JEL: D80, D84

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INTRODUCTION

As referenced in Linkov and Palma-Oliveira [1; p7] the National Academy of Sciences (NAS) defines resilience as “the ability to plan and prepare for, absorb, recover from, and adapt to adverse events”. Teoh and Seif [2] offer a different definition, focusing on resilience more as “a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationship between populations and state variables” and therefore a “fundamental quality of individuals, groups, organizations, and systems as a whole [which allows them] to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior”. They further build upon this definition of resilience as “a function of an organization’s overall situational awareness, keystone vulnerability and adaptive capacity in a complex, dynamic and interdependent system” [2]. In the last several years a significant number of norms which define key terms in the area of security and resilience from the point of view of emergency management, business continuity management systems and organizational resilience have been codified [3-8]. For example, the norm ISO 22300:2021 Security and resilience – Vocabulary defines the terms used in security and resilience standards. It defines resilience as the ability to absorb and adapt in a changing environment. A large number of norms which have yet to be codified will be dealing with authenticity, integrity and trust for products and documents, security management systems, crisis management and protective security. Such a large number of both already published and upcoming norms speaks to the need for standardization in the area of resilience management.

The process of risk analysis, risk evaluation and risk management is also codified via several international norms. The risk management vocabulary [9] defines risk as the effect of uncertainty on objectives which represents a deviation from the expected, that can be both positive and/or negative. Furthermore, risk is defined in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence [9]. The importance of risk assessment was confirmed in the revision of the ISO 9001:2015 [10] norm, where a special emphasis was placed on introducing risk based considerations and thinking. The norms ISO 31000:2018 Risk management – Guidelines [11] and IEC 31010:2019 Risk management – Risk assessment techniques [12] are being applied in an ever increasing number of companies because the risk management process is applicable regardless of the size and type of the company. These are norms which are non-binding and describe generic methods of risk management and evaluation.

Ever increasing challenges in the areas of risk assessment & management have led to a need for a risk assessment & management approach which deals not only with threat prevention but also adaptation, absorption and recovery from adverse events. Connelly et al. [13] identified features of resilience that are common across conceptualizations of resilience in various fields including (i) critical functions (services), (ii) thresholds, (iii) recovery through cross-scale (both space and time) interactions, and (iv) memory and adaptive management. These features are related to the National Academy of Science definition of resilience through the temporal phases of resilience [13]. The concept of critical functionality is important to understanding and planning for resilience to some shock or disturbance. Thresholds play a role in whether a system is able to absorb a shock, and whether recovery time or alternative stable states are most salient. Recovery time is essential in assessing system resilience after a disturbance where a threshold is not exceeded. Finally, the concepts of memory describe the degree of self-organization in the system, and adaptive management

provides an approach to managing and learning about a system's resilience opportunities and limits, in a safe-to-fail manner [13]. This has led to the rise of the concept of resilience analysis & management, which, unlike risk assessment & management, focuses on the overall system under study rather than its individual components.

This article aims to build upon the existing literature and provide a comparison of the two analytical and management approaches as well as to elaborate on the suitability of existing methodologies for measuring resilience in complex systems.

COMPARING RESILIENCE ANALYSIS AND RISK ASSESSMENT

Risk assessment which falls under the broader concept of risk management is defined as an overall process of risk identification, risk analysis, and risk evaluation by the risk management vocabulary [9]. As Linkov and Trump [14]. have noted, there exist the issue "of the definition of resilience analysis; where the various agencies interested in utilizing resilience analysis also make use of differing definitions of the term (...) agencies in the United States and research centers in Europe have begun to grapple with the issue of what resilience analysis definitely entails, yet no single definition has emerged as a standard for researchers to follow" [14]. Therefore, the working definition of resilience analysis in this article will be its characteristics as defined by the authors below.

While exploring the differences between the two approaches several authors have pointed out that they contrast on two key aspects: how they assess and understand uncertainty and how they judge outcomes of hazardous events [15]. This is due to the fact that resilience analysis focuses on exploring threats to system stability and vulnerabilities at the level of an individual system (or systems) while risk assessment focuses on individual aspects of said system. Furthermore, resilience analysis focuses on a longer timescale than risk assessment. It seeks to foresee threats, prevent longstanding losses by ensuring the system can quickly and efficiently recover from external shocks. Risk assessment focuses on a relatively short time period with the aim of protecting a specific system component from defined threats and gives little attention to post-attack recovery of a component or system. Therefore, differences between the two are elucidated by the timeframe considered by resilience analysis being far greater in scope than risk assessment. Risk assessment tends to focus on both the likelihood and consequences of a given threat to an individual system component, such as a piece of infrastructure or institution with the aim of ensuring protection, response capability for the individual system components. Given its long term perspective, resilience analysis also focuses on less probable but high consequence threats, especially with the aim of avoiding cascading potential system failure. Furthermore, risk assessment focuses on preventing failure of a specific system component, while resilience analysis focuses on preventing but also on recovering entire systems from low probability adverse events which have the potential to cause cascading effects on an entire system as well as between several interconnected systems [16]. Both approaches are specialized for different domains. While resilience analysis deals with broader more complex threats and concepts as well as a longer timeframe, risk management gives individual system elements the necessary level of detailed focus and places emphasis on better known, more probable and less harmful events which can be evaluated in greater certainty both in terms of impact and cost. Despite all of this, resilience analysis and risk assessment are compatible considering the fact they both seek to prevent negative outcomes and remove weaknesses from systems/components while focusing on differing levels of analysis and time scales. Both employ quantitative, semi-quantitative and qualitative methods to track and evaluate risk.

For Linkov and Palma-Oliveira [1], the relationship between risk assessment and resilience analysis can be seen as complimentary due to two factors: Firstly, they start from opposite starting points. Risk Assessment, as a bottom-up approach starts from data. The risk assessment process starts with data collection and progresses through modelling to characterization and visualization of risk for the purpose of risk management. Resilience takes a top-down approach starting with assessing the values of stakeholders as well as their critical functionality criteria, then through decision models it progresses towards the generation of metrics and data that ultimately can inform risk assessments. Secondly, one can consider risk assessment to be the preliminary phase to resilience analysis. It provides the first elements needed to trigger, or not, the need for resilience analysis. This is particularly true in the case of low-probability, high consequence risks of the distant future, such as those associated with climate change, large-scale cybersecurity threats, or severe weather events on the coasts [1; pp14-18]. Even though resilience analysis is typically used on a system wide level it is necessary to state that resilience analysis can be applied to lower level system areas and can therefore function in the areas typically considered the domain of risk assessment and in conjunction with it.

COMPARING RESILIENCE MANAGEMENT AND RISK MANAGEMENT

Risk management is defined by, the risk management vocabulary [9], as the coordination of all activities intended to direct and control an organization with regard to risk. The risk management process is defined as a systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context and identifying, analyzing, evaluating, treating, monitoring and reviewing risk [9].

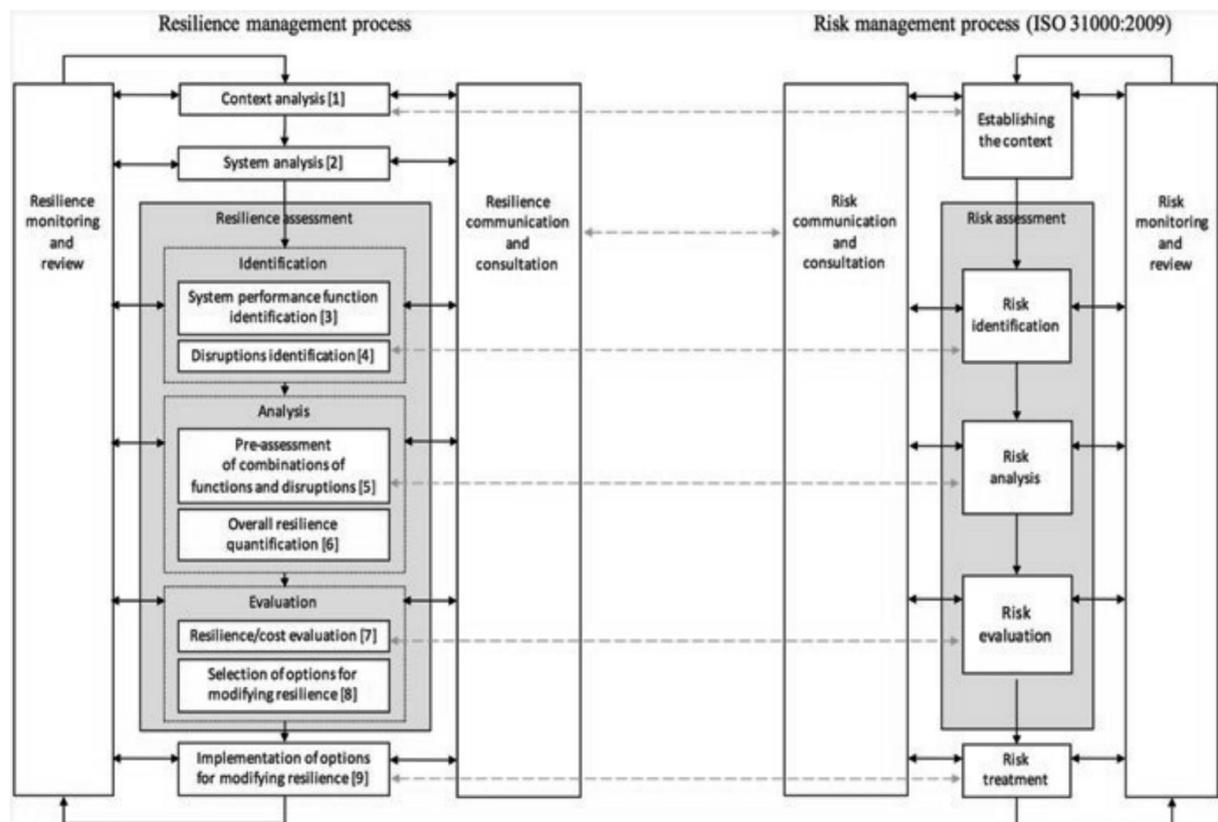


Figure 1. Comparison of the resilience management process and the risk management process [17].

Due to the relative novelty of the field a comprehensive definition of resilience management has yet to be generated. This issue is illustrated by an example of an existing definition provided by Teoh and Zadeh [2]. The definition states that resilience management is – “the ability of an organization to survive an unscheduled disruption or major crisis through its adaptability using proven and integrated risk management, crisis management, and business continuity management processes”. The definition merely subsumes other concepts of risk and crisis management within itself. They further build on this however, by defining resilience management to be the act of developing overall situation awareness, demystifying inherent threats, and reducing risk and improving organizational efficacy with restoration plans. Furthermore, Häring et al. [17] define resilience management as an “iterative process that can be decomposed into sequential steps”. They go on to specify nine steps for the resilience management process which they place within a resilience management cycle. Therefore, the working definition of resilience analysis in this article will be its characteristics as defined by Häring et al [17] in the resilience management cycle as outlined below.

Figure 1, developed by Haring [17], allows for a comparison of the 8-step resilience management process as described above with the risk management process as determined by the ISO 31000 standard.

A step by step comparison of the resilience and risk management procedure reveals several key factors. One key distinction between risk management and resilience management is the fact that the latter analyses potential disruption events with the aim of maintaining the functioning of a given system during and after a disturbance, with the goal of having it recover to a lower, same or even better state of equilibrium. Risk management, on the other hand, seeks to prevent the failure of the individual system component by shielding it from identified risk factors. When reviewing characteristic 1 and 2 of the resilience management process, given the fact that resilience management is more system focused than risk management, it distinguishes between defining the context and understanding the system under study, this is necessary due to the fact that threats can have impacts felt through one or many systems due to their inter-connected nature and due to the fact that the threat level of an individual disturbance event depends on the characteristics of the system itself. Risk management is focused more narrowly on individual system components and seeks to, above all else, determine the context so as to be able to carry out its tasks and identify specific knowable risks to a system component. When reviewing step 5 of the resilience management process it is evident that resilience management differs from risk management in that the latter seeks to analyze potential risks and neglects the interplay between system section characteristics and the risks themselves while resilience management seeks to assess critical combinations of both system functions and disruptions as well as an overall resilience assessment of critical combinations.

COMPARING AND CONTRASTING EXISTING METHODOLOGIES FOR MEASURING RISK AND RESILIENCE

As has been stated above in the article, both resilience analysis and risk assessment employ quantitative, semi-quantitative and qualitative methods to track and evaluate risk. The IEC 31010:2019 Risk management – Risk assessment techniques standard [12] compliments the ISO/IEC 31000 norm and provides further guidelines for the selection and application of methods and techniques of risk assessment. The applicability of tools used for risk assessment was presented in Table 1.

Table 1. Applicability of tools used for risk assessment [12]. SA – strongly applicable, A – applicable, NA – not applicable.

Tools and techniques	Risk assessment process				
	Risk identification	Risk analysis			Risk evaluation
		Consequence	Probability	Level of risk	
Brainstorming	SA	NA	NA	NA	NA
Structured or semi-structured Interviews	SA	NA	NA	NA	NA
Delphi	SA	NA	NA	NA	NA
Check-lists	SA	NA	NA	NA	NA
Primary hazard analysis	SA	NA	NA	NA	NA
Hazard and operability studies(HAZOP)	SA	SA	A	A	A
Hazard Analysis and Critical Control Points (HACCP)	SA	SA	NA	NA	SA
Environmental risk assessment	SA	SA	SA	SA	SA
Structure « What if? » (SWIFT)	SA	SA	SA	SA	SA
Scenario analysis	SA	SA	A	A	A
Business impact analysis	A	SA	A	A	A
Root cause analysis	NA	SA	SA	SA	SA
Failure mode effect analysis	SA	SA	SA	SA	SA
Fault tree analysis	A	NA	SA	A	A
Event tree analysis	A	SA	A	A	NA
Cause and consequence analysis	A	SA	SA	A	A
Cause-and-effect analysis	SA	SA	NA	NA	NA
Layer protection analysis (LOPA)	A	SA	A	A	NA
Decision tree	NA	SA	SA	A	A
Human reliability analysis	SA	SA	SA	SA	A
Bow tie analysis	NA	A	SA	SA	A
Reliability centered maintenance	SA	SA	SA	SA	SA
Sneak circuit analysis	A	NA	NA	NA	NA
Markov analysis	SA	SA	NA	NA	NA
Monte Carlo simulation	NA	NA	NA	NA	SA
Bayesian statistics and Bayes Nets	SA	SA	NA	NA	SA
FN curves	A	SA	SA	A	SA
Risk indices	A	SA	SA	A	SA
Consequence/probability matrix	SA	SA	SA	SA	A
Cost/benefit analysis	A	SA	A	A	A
Multi-criteria decision analysis(MCDA)	A	SA	A	SA	A

In order to ensure an effective way of managing risk, it is necessary to select an acceptable risk identification, analysis and evaluation method. The ISO 31010 norm [12] provides 31

methods for risk assessment, some of which are widely applied in terms of risk identification, evaluation and assessment, while others only focus on a certain risk assessment phase. From all of these methods, it is necessary to point out the FMEA (Failure modes and effects analysis) – which is a widely used method, applicable in all situations which can be used to identify significant number of errors within a system. There are no standardized approaches, methodologies and techniques for the evaluation of resilience, nor is a standardization of these methods foreseen in the versions of the ISO norms currently under development. In the literature authors list several methods which are applied in certain case studies as well as systematize approaches and methods to be used in different steps in the development of resilience management systems. Based on the literature reviewed, Figure 2, located below, provides approaches and methods for different steps which are considered to be relevant and potentially applicable for resilience assessments.

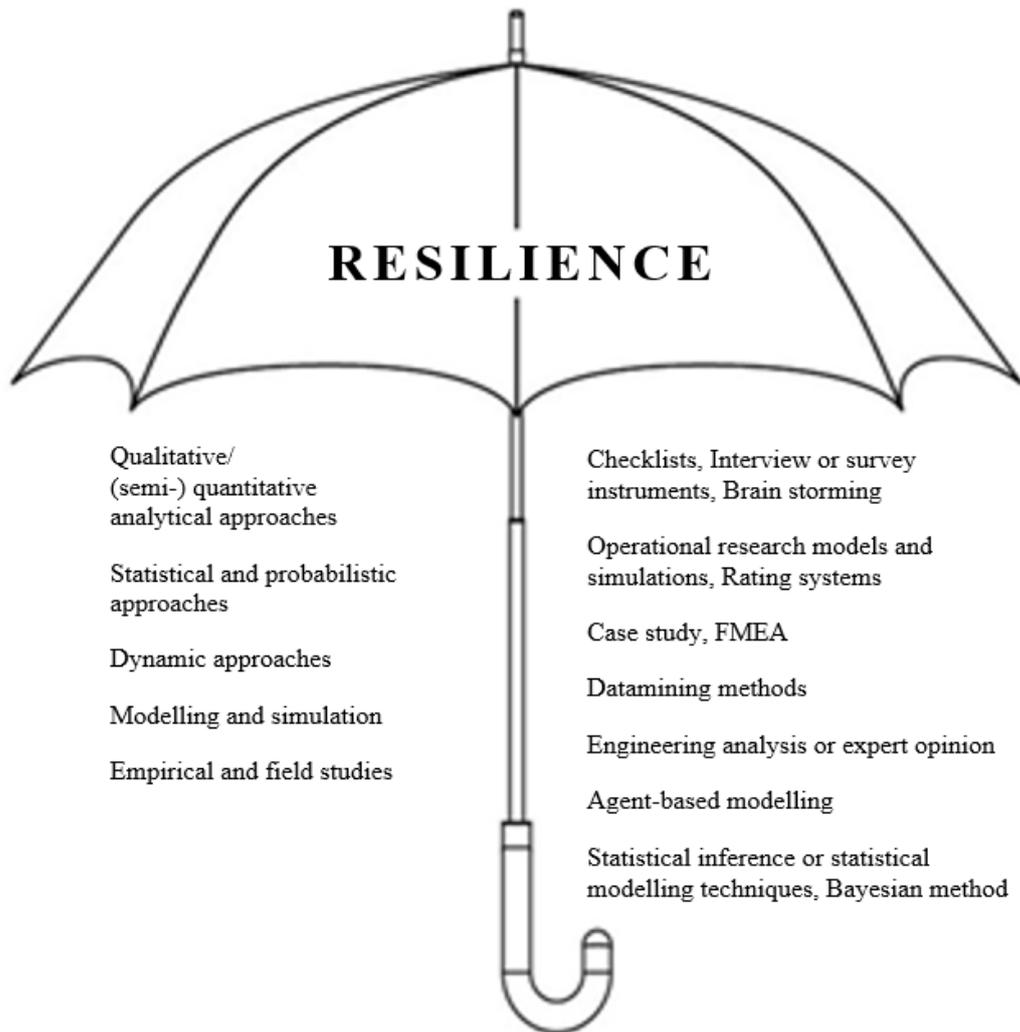


Figure 2. Approaches and methods (techniques) to resilience assessment.

In order for a certain approach or methodology to be fit for use, these are some of the key criteria which must be fulfilled:

- 1.) the application procedure of a certain methodology (method) must be clearly defined and understandable to the users,
- 2.) the methodology must ensure objective and repeatable results,
- 3.) the methodology must be successfully demonstrated both in a controlled and real world environment,

- 4.) the methodology must be independently evaluated,
- 5.) the methodology must demonstrate robustness,
- 6.) the results obtained via the application of different methods should be comparable.

Examples of resilience and risk assessment will be developed in further research using various methods. Examples for resilience assessments of materials to corrosion as well as risk assessment of the likelihood of corrosion will be provided using the Brainstorming technique, the Cause and effect analyses and the FMEA method.

CONCLUSION

Considering the analysis conducted in the article it is possible to conclude that demands to provide standardizations for the areas of risk and resilience are ever-increasing. A large number of norms pertaining to the area of resilience is currently being codified. As the article has demonstrated the initial analytical steps in the area of both risk and resilience share certain characteristics but differ in others. Risk assessment focuses on preventing failure of a specific system component, while resilience analysis focuses on preventing but also on recovering entire systems from low probability adverse events. Furthermore, the broader concept of risk management is focused more narrowly on individual system components while resilience management is more system focused. Despite their similarities, both approaches differ in terms of scale and the temporal dimension. As regards to the methodologies employed, both resilience analysis and risk assessment share a strong level of similarity in this domain as well, with both relying on quantitative, semi-quantitative and qualitative methods to track and evaluate risk. This being said it must be concluded that there is still no clearly defined delineation between the two concepts in the literature for which there is a pressing need due to their inherent difference and interoperability.

Taking all of this into account it is possible to conclude that the risk assessment & management approach and the resilience analysis & management approach differ between each other, among other things, in terms of the level of analysis, the time-frame within which they study the impact of events as well as the steps they take to manage these concerns. Despite this, it is necessary to state that the resilience analysis and management approach can be applied to lower level system areas and can therefore function in the domain typically associated with risk assessment and in conjunction with it.

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CYBER-SECURITY RISKS ASSESSMENT BY EXTERNAL AUDITORS

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ABSTRACT

The rise in cybercriminal activities in recent years has sparked concern about the costs of technological advancement and the growing reliance of humans on technology. The seriousness of this situation in the business world is indeed more noteworthy and more prominent than other areas, prompting many people to wonder how external auditors – who are responsible for identifying any accounting flaws – will respond to cybersecurity-affected businesses – the ones which can make an honest effort to mask and conceal their difficulties and challenges from their investors and stakeholders. Consequently, the aim of this study is to search whether external auditors focus harder on cybersecurity-attacked firms and businesses by charging higher audit fees. The study found a positive correlation between audit fees and breach employing a sample of 100 global small-, medium-sized, and large businesses. This indicates that external auditors find more risks and spend more effort while auditing cybersecurity-attacked businesses.

KEY WORDS

audit fees, cybersecurity risks, OLS model

CLASSIFICATION

JEL: A29, C12, G30, Y80

INTRODUCTION

Since the beginning of the 21st century, the world has been experiencing a large number of severe cyber criminals which demonstrates the fact about the growing dependence of human beings on the usefulness of technological advance. The severity of this situation in the business world is even greater and greater than other fields, which leads many people raise a question about the response of external auditors – the ones who are responsible for detecting any accounting faults – towards cybersecurity-attacked companies – the ones which can try their best to hide their difficulties from their investors and stakeholders. In the business world, the technological advance has been possessing a dominant position thanks to their supply of powerful managerial tools for each single organization when the majority of today operational procedures are accomplished with the help of information technology systems. Unfortunately, along with the development of the information technology systems, threats related to data and information security at companies and enterprises have appeared and evolved through time. Although the security risks have received the most concern from all companies with a lot of actions to protect themselves from data and information security attacks, the complete mitigation of vulnerabilities has been still unfeasible and the number of cyber-attacked companies has been increasing day by day. There are many evident facts that a cybersecurity attack can easily knock a big company down and no investors or stakeholders of a company expect any news about cybersecurity attack. As indicated in the efficient market theory of Fama [1] the stock market is the reflection of all investors' information about a company. Hence, the cyber-attacked company will have a tendency to hide any bad information or terrible consequences related to their cyber-attacks, which then leads people to feel curious about the role of external auditors in the case of auditing a cyber-attacked companies – whether external auditors are put under much pressure to detect any faults of these companies, which forces them to charge a higher fees for their higher auditing efforts.

Tempted from this current issue, this research is designed to answer the question whether external auditors will pay more attention to cyber-attacked companies to assure the credibility of their auditing opinions by charging higher audit fees to these companies. Using a sample of 100 global small, medium and big companies from Wharton Research Data Service, this study has proved that higher audit fees will be charged for cyber-attacked companies, which means that external auditors will pay more attention to audit these companies.

The remaining parts of this study are organized as follows. Firstly, the research demonstrates the current socio-economic background of cybersecurity as well as the general background information about audit fees and previous academic literature about the relationship between audit fees and cybersecurity risks, which then paves the way for the development of the hypotheses on the impact of audit security risk on audit fees. The following part illustrates the research method and the formation of the regression model. Finally, using a sample of 100 global small, medium and large companies, the study finds out that there is a positive relationship between audit fees and breach, which means that external auditors find more risks and exert more efforts when auditing the cybersecurity-attacked companies. The research draws conclusions as well and points out any limitations and makes several suggestions for future research.

LITERATURE REVIEW

SOCIO-ECONOMIC BACKGROUND OF CYBERSECURITY

The advent of Internet and the rapid revolution of information technology have brought a high degree of advantages to the human life. The presence of technology can be seen in any

aspects of life and has become a lifeblood in both civilized society and the world of business. However, it is the advance of technology which opens many rooms for cybercrime, and cybersecurity is among one of the most day-to-day struggling issues of every individual around the world. A report about Cyber Security of the European Commission [2] states that each single day experiences one million people becoming victims of cyber criminals, and there is one hacker attack of Internet-accessing computer in every 39 seconds [3].

In the business world, the picture of cybercrime is even gloomier due to the dependence of most current businesses on electronic data and computer networks for the sake of their daily operations, which then leads to the exposure of personal, confidential and competitive information to the hackers. Cyber criminals have knocked a lot of businesses down and shot them to the hell (e.g.: the hack of 77 million PlayStation Network accounts caused losses of \$ 171 million while the site was down for a month in 2011; the exposure of 3 billion Yahoo user accounts knocked \$ 350 million off Yahoo’s sale price in 2014; the theft of 57 million Uber users personal information and 600 000 driver license numbers ruined Uber’s both reputation and money in 2016; the show-up of 419 million – 540 million records of Facebook IDs and phone numbers in April and September 2019 is the most horrible scandal in Facebook history).

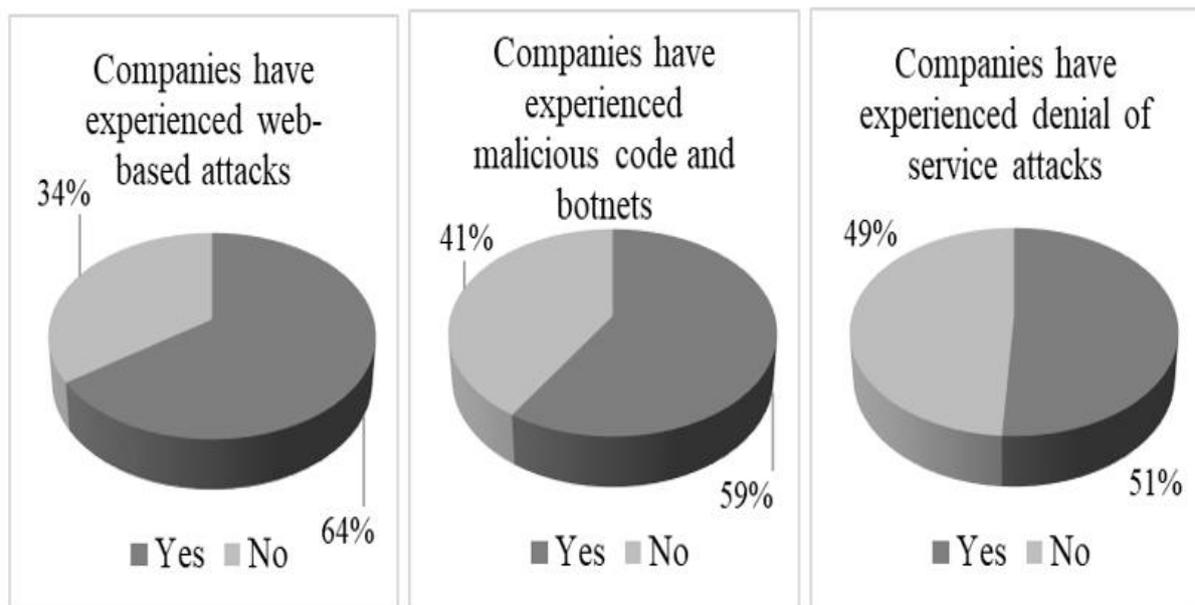


Figure 1. Cybercriminals in business world [4].

In fact, according to recent statistics, the business world has been in highly vulnerable to cyber-attacks these days. In 2018, “64 % of companies have experienced web-based attacks. 62 % experienced phishing & social engineering attacks. 59 % of companies experienced malicious code and botnets and 51 % experienced denial of service attacks.” [4]; “68 percent of business leaders said their cybersecurity risks are also increasing” [5]; “Only 5 % of folders were protected” [6]; “3,813 breaches were reported through June 30, exposing over 4,1 billion records. Compared to the midyear of 2018, the number of reported breaches was up 54 % and the number of exposed records was up 52 %.” [7]; “Worldwide spending on information security products and services will reach more than \$ 114 billion in 2018, an increase of 12,4 percent from last year, according to the latest forecast from Gartner, Inc. In 2019, the market is forecast to grow 8,7 percent to \$ 124 billion.” [8]. Those impressive numbers actually have provoked an alarm about the severe risks of the world business’s cyber security.

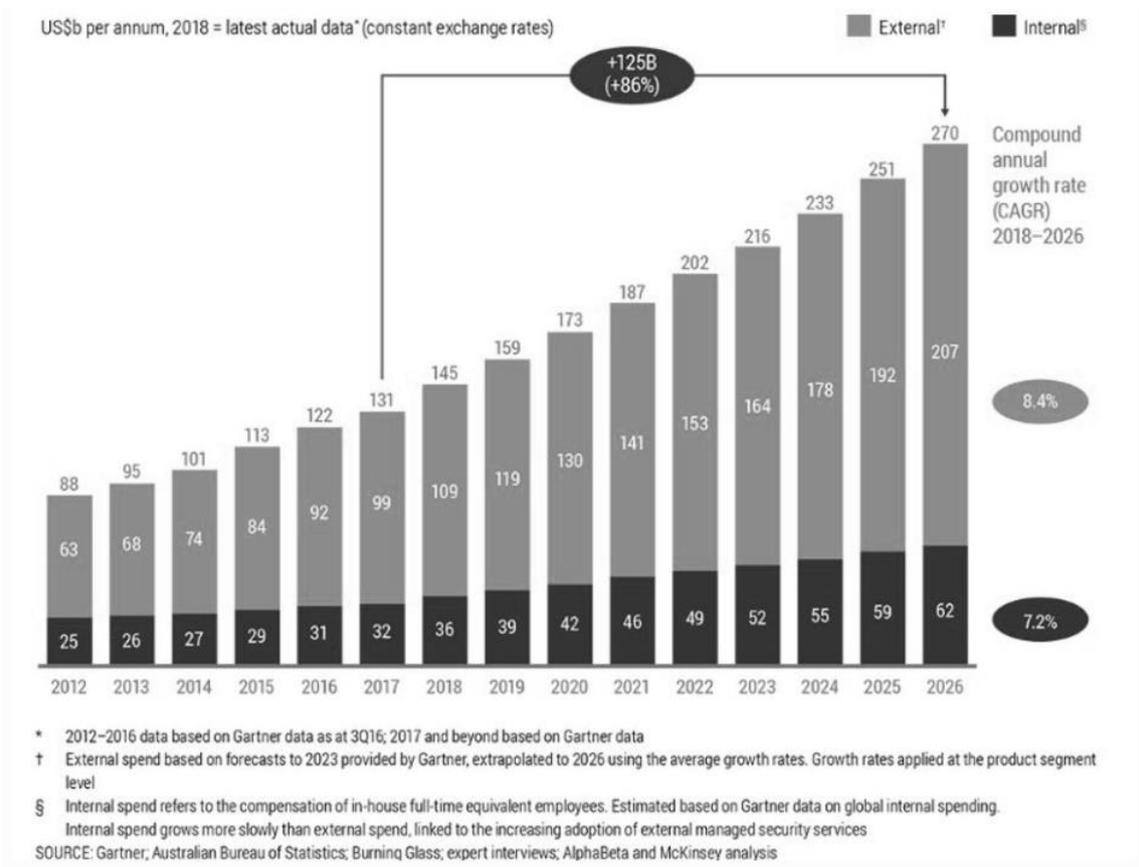


Figure 2. Worldwide spending on information security products and services [9].

Fully aware of the severity of cyberattacks, many companies have adopted different methods to manage cybersecurity threats. While several companies have tried to build their own cyber security metrics and measures with the hope of verifying their security controls, exploring their security strengths and weaknesses; and detecting security trends [10]; others label their information basing on subdivided degree of sensitivity which allows people at different level having particular authorization to access to sensitive information for better information management and protection [11]. Besides, in Smetters's research [12], the author demonstrates that the failure of existing security system is attributed to users difficulties in managing security and their inability to figure out their security-critical tasks accomplishment, which leads to only 51 % of users actually update their antivirus software although 92 % of them think that they have already done and 73 % users think that they have turned on a firewall while only 64 % actually do that. Therefore, according to Smetters [12], an organization need well-designed information visualization tools for a stronger system administration management.

In a macro perspective, to tackle with the ever-present threats from cyber criminals, governments, regulators and legislators around the world have been enacted many laws and rules for governing privacy and security protections (e.g.: In US: The National Strategy to Secure Cyberspace [13]; International Strategy for Cyberspace. Prosperity, Security, and Openness in a Networked World [14]; In France: French National Digital Security Strategy [15]; In Germany: Cyber Security Strategy for Germany [16] and IT Security Act [17]; In China: The Decision of the Standing Committee of the National People's Congress on Strengthening the Network Information Protection [18]; In Canada: Canada's Cyber Security Strategy. For a Stronger and More Prosperous Canada [19]; In Albania: National Security Strategy [20] and Cyber Security Strategy [21].

CYBERSECURITY AND AUDIT FEE

Although the implication of cybersecurity stretch across all business regions, the most attention of the cybersecurity in business world focuses on the financial sector because according to Kamiya et al. [22], financial information attack leads to a negative stock-market reaction, a decline in sales growth for large firms and retail firms, a rise in leverage, a deterioration in financial health, and a reduction in investment in the short run. Hence, it is no doubt that a scandal in financial information security hack can easily knock even a big company down in a short period of time. As results, in these recent years, regulators and standard setters have been exert much more concern about cybersecurity threats on the level of attention of external auditors [23-28]. There are many reasons for regulators and standard setters forcing external auditors to pay more attention to cybersecurity-incident-occurring companies. Firstly, it is the mission of external auditors to assess the client's accounting for losses, claims, and liabilities related to a cyber-security incident once it happens in the context of a company finding difficult to cope with considerable and unexpected direct and indirect cost [29]. Secondly, in case of direct cyber-attacks to a company's accounting system, external auditors are required to take into consideration the Internal Control over Financial Reporting (ICFR) because the incident could involve in the risk of the company's accounting record manipulation, which results in the less trustful financial statements [24]. Even if cyber-attacks do not affect the accounting recording system, the auditors are still required to put additional efforts in their auditing work since there is indication about weaknesses in the company's internal control, which could be risks in ICFR [30]). As external auditors are put under enormous pressure when auditing cybersecurity-incident-occurring companies, it is necessary to discover how external auditors responds to cybersecurity incidents, and one of the common indicator is audit fee charges [30, 31].

“Audit fee is the economic remuneration for auditors who provide audit services, which are an agency fee according to certain standards. The audit fee includes the total cost of audit through the overall audit work, the risk compensation and the profit demand” [32].

In other words, audit fees serve as compensation for auditing services which include both auditing work performance and auditing risk [33]. Since the risk is increasing in cybersecurity-incident-occurring companies as stated above, there are many hypotheses in academic literature about the impact of cybersecurity incident on external auditors' response through audit fees [30, 31, 34]. To be more specific, using 229 cyber incidents from the Audit Analytics cybersecurity database and Privacy Rights Clearinghouse for the period between 2010 and 2014, Li et al. [30] finds out that cyber incidents exerts positive impact on the audit fees. It means that higher audit fees are charged for the companies experiences cybersecurity hacks. Smith and Pinsker's research [34] result also shares the same conclusion as Li et al.'s [30] when demonstrates that there is positive association between both past and future breach disclosures and audit fees. On the other hand, investigating 5 687 companies from the Audit Analytics Audit Fees database for 12-year period between 2003 and 2015, Rosati et al. states that audit fees increasing just occurs in temporary and auditors take into consideration of cyber-security risk in their audit risk assessment in advance of the occurrence of an incident [31].

Owing to the fact that there are few researchers investigating the relationship between cybersecurity risk and audit fees, and the final conclusion about this relationship has not been reached yet, this research will fill this gap in academic literature by building the hypothesis as followed:

H₁: The cybersecurity incidents have positive impact on the high audit fees.

METHODOLOGY

On the basis of the literature reviews and in order to test the hypothesis above, a detailed description of this research's methodology is provided in this chapter. As quantitative analysis can help 'to explore, present, describe and examine relationship and trends within our data' [35], quantitative method is adopted throughout this study.

DATA

The sample firms used to answer the research questions are 100 worldwide firms listed Wharton Research Data Service. This database is chosen because it comprises 100 small, medium and big companies with diverse major throughout the world, which will present a vivid picture relating to the effect of cyber security attacks on audit fees in the world. Also, the financial information with these companies can be collected via Wharton Research Data Service website, which then can support to answer this research's question. However, due to the lack of many missing financial data or no audit fee information, this study just focuses on only 78 companies instead of 100 companies. The reduced number of companies still holds the qualities of the full data set since according to Groubner et al. [36; p.307, 37] "samples of 25 to 30 produce sampling distributions that are approximately normal", therefore a sample of 78 is considered a sufficiently large sample. Meanwhile, the data set contains historical financial data between the time period of 2005 and 2014 i.e. for the majority of companies a ten-year period is covered providing large enough sample to study. On the other hand, keeping the businesses in the dataset with a shortage of relevant financial and audit fee information would have provided unreliable results while reducing the data set to companies possessing all the data required has beneficial impact on the analysis; it does not cause bias while the analysis remains reliable and is capable to reflect a real phenomenon.

All the data used in this research are secondary data. Yearly historical financial data of 100 companies are scrutinized for the period between 2005 and 2014, because this period experienced a variety of significant occurrences in the worldwide cyber security as mentioned in the literature review above. While yearly historical financial data of 100 companies are obtained from Wharton Research Data Service, the companies breach information is collected from Data Breaches shared by Privacy Rights Clearinghouse.

RESEARCH DESIGN

Audit fees are used in this research to represent the degree of auditors' concern about cyber securities incidents, because they are proved to be powerful tools to measure the attention of auditors to cyber-attacked companies in academic research. Several researchers imply that higher audit fees related to: higher IT investments as the IT complexity brings difficulties for auditors to detect accounting irregularities [38]; higher information asymmetry [33]; more severe cyber incidents [30]; less active audit committees [34]. Consistent with prior studies, in this research, audit fees are used as proxies for the measurement of external auditors' concern for cyber security risks.

The multivariate regression models used to test the research hypothesis is semi-logarithmic model developed from the model in Rosati et al.'s research [31]. As stated in Rosati et al., audit fees "vary with size, complexity, riskiness and other client-specific characteristics" [31; p.17] as the size of the business, the auditee complexity, the business's asset structure, its financial condition, the arising business risk, earnings quality, corporate directorship and a company's regulatory environment [31]. The method adopted to estimate the regression model mentioned above will be Ordinary Least Square (OLS) method.

The target of this study is to examine external auditors concern for cyber security risks by exploring whether cyber security incidents can lead to high audit fees. Therefore, the hypothesis stating that cybersecurity incidents have a positive impact on high audit fees is to be tested by a multivariate regression model including predicting variables in case of which data were available. Variables with extensive missing data were excluded, however, employing a reduced number of variables with exhaustive data probably results in stronger explanatory effect (higher R_2 in the regression model) than including variables with extensive missing values. The revised multivariate regression model used to test Hypothesis 1 is estimated as the following:

$$LAF_{i,t} = \beta_0 + \beta_1 BREACH + \beta_2 LTA + \beta_3 LLEV + \beta_4 CUR + \beta_5 QUICK + \beta_6 ROA + \beta_7 DEBTEQ + \varepsilon_{i,t} \quad (1)$$

where:

$LAF_{i,t}$ = logarithm of audit fees of firm i in year t , a proxy for the external auditors concern for cyber security risks;

$BREACH$ = 1 if a firm experiences a cyber-security incident in year t , 0 otherwise;

LTA = logarithm of end of year total assets of firm i in year t ;

$LLEV$ = logarithm of the ratio (current liabilities divided by total assets) of firm i in year t ;

CUR = the ratio (current assets divided by total assets) of firm i in year t ;

$QUICK$ = difference between current assets and inventory divided by current liabilities of firm i in year t ;

ROA = earnings before interest and taxes divided by total assets of firm i in year t ;

$DEBTEQ$ = the ratio (total debt divided by equity book value) of firm i in year t .

The predicting variables in the model include in a large number factors that control for audit risk such as the ratio of current assets to total assets (CUR), the quick ratio ($QUICK$), profitability (ROA) and the debt-to-equity ratio ($DeBTEQ$), while for audit effort the size of the company (LTA) is employed. The occurrence of a cyber attack is also included ($BREACH$) to confirm an increase in audit fees after a cyber incident occurrence. The model was calibrated to the present data set and can be applied in similar cases as well; and should data be available further and additional variables reflecting business complexity or regulatory environment can be added to the model.

The purpose of the regression model is to figure out the relationship between the main independent variable (audit fees) and dependent variable (breach), which represents for the impact of cyber-security incidents on audit fees. However, besides the main independent variable, the regression model as followed the model in Rosati et al.'s research [31] contains six other independent variables in order to clearly indicate the relationship between an independent variable and a dependent variable.

FINDINGS

CORRELATION BETWEEN AUDIT FEES AND CYBER INCIDENTS

The first signal for the relationship between the two examined variables is correlation coefficients as "The correlation measures the direction and strength of the linear relationship between two quantitative variables correlation" [39]. The purpose of correlation analysis in this research is to measure the linear association between the proxy

for auditors' concern (audit fees) and other independent variables with the main dependent variable accounting for cybersecurity attack risks (breach).

Table 1 below will show the pairwise correlations between the variables indicated in the regression model. The result expects to obtain positive correlation between the two main variables: audit fees and breach, which means that cybersecurity attacks exert positive effect on the higher audit fees. All the predictors show significant correlation with the dependant variable LAF ($p < 0,05$) but LLEV.

Table 1. Pearson correlations between variables of the model (Source: Eviews stat).

Correlations								
	LAF	BREACH	LTA	LLEV	CUR	QUICK	ROA	DEBTEQ
LAF	1							
BREACH	0,085*	1						
<i>Sig. (2-tailed)</i>	0,032							
LTA	0,577**	0,035	1					
<i>Sig. (2-tailed)</i>	0,000	0,377						
LLEV	-0,022	0,060	-0,281**	1				
<i>Sig. (2-tailed)</i>	0,572	0,130	0,000					
CUR	0,174**	-0,060	-0,014	-0,054	1			
<i>Sig. (2-tailed)</i>	0,000	0,131	0,728	0,170				
QUICK	-0,127**	-0,050	-0,056	-0,360**	-0,023	1		
<i>Sig. (2-tailed)</i>	0,001	0,204	0,157	0,000	0,563			
ROA	0,081*	-0,059	0,188**	-0,219**	0,020	0,007	1	
<i>Sig. (2-tailed)</i>	0,042	0,139	0,000	0,000	0,621	0,868		
DEBTEQ	0,133**	0,034	0,310**	-0,033	-0,023	-0,036	0,023	1
<i>Sig. (2-tailed)</i>	0,001	0,392	0,000	0,412	0,569	0,359	0,557	

*significant at the 0,05 level (2-tailed)

**significant at the 0,01 level (2-tailed)

As can be seen from the Pearson correlations matrix in Table 1, the correlation between the audit fees and the breach is positive (0,08), which means that a rise in breach is associated with an increase in audit fees. In other words, an implication could be made from the correlation between audit fees and breach is that a climbing number of cybersecurity attacks of 100 investigated companies from 2005 to 2014 relates to a growth extent of auditors' concern. This preliminary finding is consistent with the explanation that it should take more

time and efforts for auditors to examine the correctness of the financial data of a company which has experienced a criminal cyberattacks.

REGRESSION MODEL ANALYSIS

Since Hypothesis 1 in this study aims to examine the positive influence of cybersecurity incidents on audit fees, the coefficient β_1 in the regression model (1) is expected to be positive ($\beta_1 > 0$). This is because positive β_1 means that cybersecurity incidents result in higher external auditors' concern for their auditing companies via higher audit fees, which supports Hypothesis 1. Figure 3 displays and illustrates the higher audit fee in terms of the total asset of the firm i at time t and cyber security incident. The correlation proves to be significant with $R^2 = 31,7\%$ in case of no cyber incident and $R^2 = 36,4\%$ in case of a cyber incident. Excluding the cyber incident factor decreases the multiple R^2 from $R^2 = 39,9\%$ to $R^2 = 39,4\%$ in the entire model implying that the inclusion of the factor cyber breach has increased the robustness of the model and serves as an explanatory factor in rising audit fees.

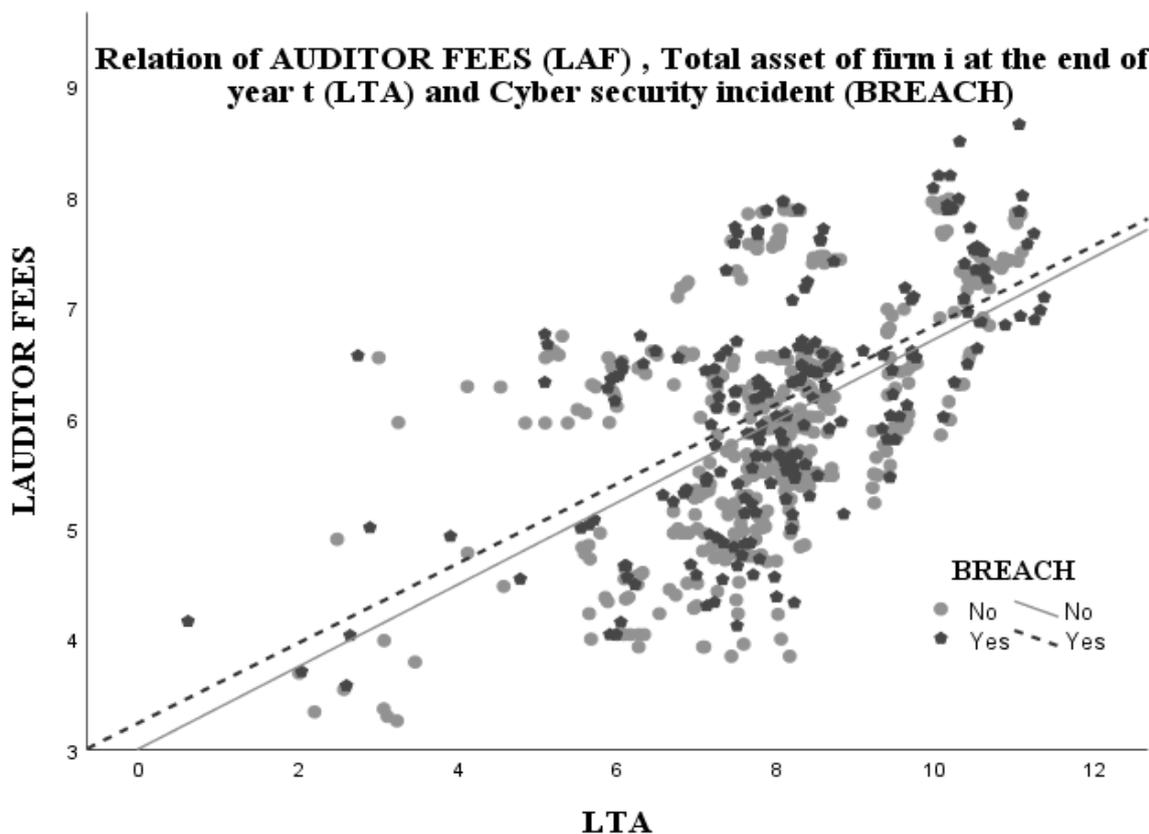


Figure 3. Relation of LAF, LTE and BREACH.

To address the timely increase in audit fees due to cyber incidents Figure 4 visualises the assessment and increase of audit fees due to cyber security incidents throughout the years under observation.

External auditors have become more aware of cyber security breaches as assumed based on the opening gap of the linear trends for audit fees with and without cyber incident. While audit fees are slightly increasing with time in case of companies without recognised cyber breach, they are continuously increasing at a higher rate and pace in case of firms with the occurrence of cyber incidents. The trend equations show the different steep of growth in audit fees resulting in an ongoing widening gap in audit fees for companies with and without cyber

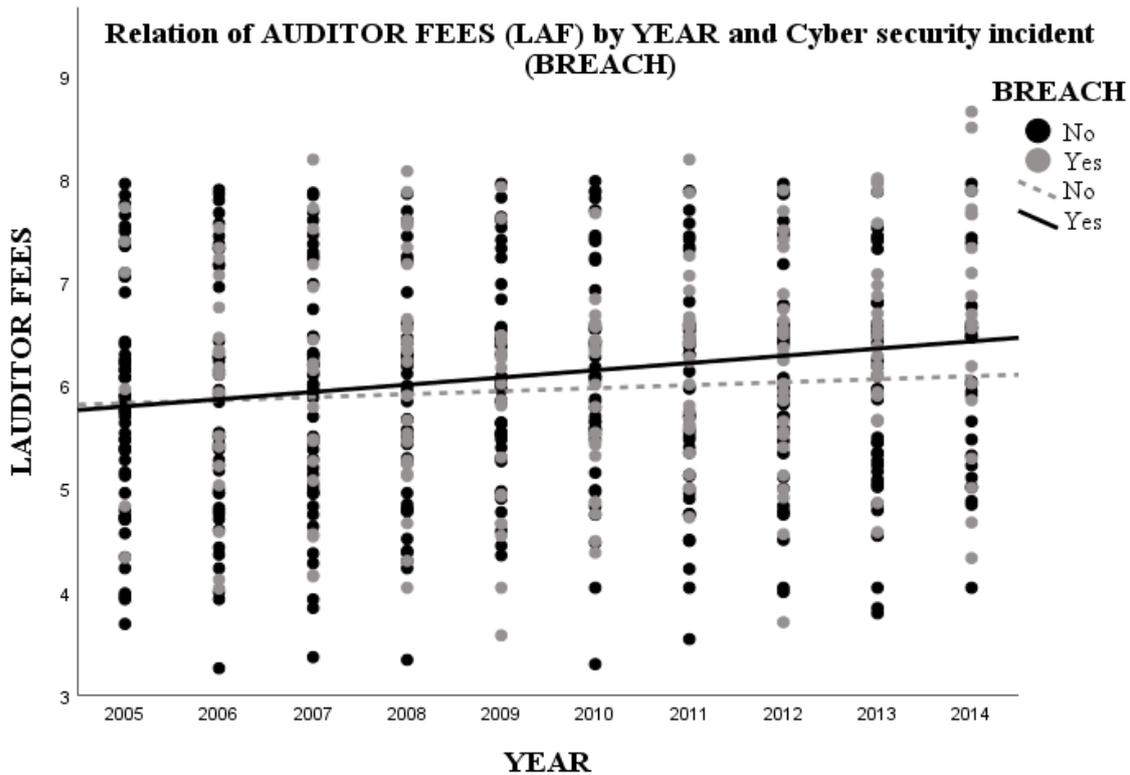


Figure 4. Relation of LAF, YEAR and BREACH.

breach. According to the regression model companies could calculate with the same audit fee size during the years 2005 and 2006 while from that point of time auditing firms focused more on cyber-attacked companies and raised audit fees to a higher extent in case of those with cyber incident.

The regression model justifies the relevance of the time period and provides a reference starting point for higher cyber security awareness amongst audit firms. In this model the variable YEAR proved to be significant at a 5 % significance level.

$$\widehat{LAF}_{No\ breach} = -52,37 + 0,03 \cdot t, \tag{2}$$

$$\widehat{LAF}_{Breach} = -135 + 0,07 \cdot t, \tag{3}$$

The results indicate a gradual and ongoing raise in audit fees even in the time period following the observed one based on external auditor assessment. The trend for audit fees in case of firms with no detected cyber breach shows a much flatter shape (2). To conclude, the nature of the trend signals that external auditor assessment resulting in detecting cyber incidents and breach raises awareness and results in higher audit fees.

Table 2 below provides Eviews results for the original regression model (1) testing the influence of cybersecurity incidents on audit fees. The model itself proved to be significant since $F = 59,672$ while $p = 0,000$, i.e. the influential factors are worth examining. The correlation analysis showed, however, that the strongest relationship exists between the total asset of firm i at the end of year t (LTA) and audit fees (LAF) while LTA and BREACH are in positive correlation, i.e. a firm with higher total asset is rather exposed to cybersecurity incidents.

As can be seen from Eviews results in Table 2, the coefficient of BREACH is significantly positive (0,148793) at 5 % level of confidence ($p\text{-value} = 0,0364$), which confirms the expectation mentioned above ($\beta_1 > 0$). The coefficient of BREACH estimated at 0,148973 means that with all other variables unchanged, the increase of one cybersecurity incident of

100 examined companies from 2005 to 2014 will lead to nearly 14,9 % increase in the audit fees. This result consists with the result from descriptive statistics analysis above. Also, the result shows an evident fact about the positive relationship between the audit fees charge and cybersecurity incidents, which means that companies that experience cybersecurity attacks have a tendency to tolerate higher audit fees charge.

Table 2. Eviews results of the multivariate regression model 1 (Source: Eviews stat).

Dependent Variable: LAUDITOR_FEES				
Method: Least Squares				
Date: 12/08/19 Time: 17:28				
Sample: 1 638				
Included observations: 638				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2,722944	0,177025	15,38167	0,0000
BREACH	0,148973	0,071041	2,097017	0,0364
LTA	0,405316	0,022127	18,31757	0,0000
LLEV	0,207780	0,050081	4,148915	0,0000
CUR	0,001502	0,000242	6,209198	0,0000
QUICK	-0,000766	0,000795	-0,963576	0,3356*
ROA	-9,32E-06	6,31E-05	-0,147731	0,8826*
DEBTEQ	-0,014589	0,008152	-1,789540	0,0740*
R-squared	0,398685	Mean dependent var		6,013722
Adjusted R-squared	0,392003	S.D. dependent var		1,065984
S.E. of regression	0,831192	Akaike info criterion		2,480547
Sum squared resid	435,2542	Schwarz criterion		2,536451
Log likelihood	-783,2946	Hannan-Quinn criter.		2,502249
F-statistic	59,67185	Durbin-Watson stat		0,363616
Prob (F-statistic)	0,000000			

*significant at the 0,05 level

For the controlling variables, except from the coefficients of variables QUICK, ROA and DEBTEQ which are statistically insignificant, coefficients of other controlling variables are positively significant at both 1 % and 5 % level of confidence.

The R-square of the regression model is used to measure the level of percentage of independent variables explaining the dependent variable in the regression model. In this regression model, the R-Square is acquired at nearly 40 % which shows that the regression model quite fits the data collected and means that 40 % of the observed variable could be explained by the model's input independent variables.

The linear regression function is the following based on the model:

$$\widehat{LAF} = 2.722944 + 0.148973BREACH + 0.405316LTA + 0.207780LLEV + 0.001502CUR - 0.000766QUICK - 0.00000932ROA - 0.014589DEBTEQ \quad (4)$$

Noting that the time period under study depicts the date when auditors started to raise awareness of the significance of cyber attacks, and noting that the business segment as a company's complexity factor is supposedly has an effect on potential cyber incident the regression model was extended and tested with two additional factors: time (YEAR) and regulatory business environment (SIC), namely the model was run with the inclusion of the year (YEAR) and the two-digit code for industry indicators (SIC). The regression model improved to $R^2 = 40,7\%$ i.e the explanatory size of the predictors slightly increased while the model remained significant ($F = 47,930$, $p = 0,000$). As predictors, business sector (SIC) proved to be significant ($t = -2,742$, $p = 0,006$) while the YEAR has turned into an insignificant variable ($t = 1,164$, $p = 0,245$). Consequently, the exclusion of the variable YEAR is justified while the analysis of audit fees for the different industry sectors in case of cyber-attacked companies is grounded.

CONCLUSION

This article addresses the question of whether external auditors provoke any response towards cybersecurity incident risks. This study is designed in the context of the mushrooming increase in the number of criminal cybersecurity occurrences around the world and the introduction of many rules and laws to protect technology users from cybercrimes. Especially in the business world where the cybercrimes consequences have been becoming more and more severe these days and the cybersecurity-attacked companies are put in such terrible conditions that they have more tendency to hide the true picture of their companies in order to keep calm their investors and stockholders. This result will then exert more pressure on external auditors who are responsible for providing reasonable assurance that financial statements of a company are presented fairly and in conformity. Hence, the research question of this study test whether external auditors pay more attention to cybersecurity incidents by examining whether higher audit fees will be applied to cybersecurity-attacked companies.

Consistent with the research's hypothesis, the corresponding regression model reveals an evident fact that higher criminal cyber incidents of 100 global companies from 2005 to 2014 result in higher audit fees charged. The ten-year time series model reveals that based on the model and the data available there was a turning point in the year 2005 and 2006 when auditing firms commenced to put more emphasis on cyber-attacked companies and auditing fees started to increase at a higher speed in case of such businesses. The model extended with the two-digit business code unveiled that audit fees for cyber-attacked companies vary depending also on the industry sector. As this result demonstrates the fact that external auditors express more concern for cybersecurity-attacked companies, it provides support for those regulations and laws related to the role of external auditors in the context of terrible cyber crimes [23-28] and previous academic literature [30, 31]. On the whole, this research

brings new perspectives and evidence to the growing body of literature about the relationship between external auditors' concern and cybersecurity risks. The study helps to reassure the business world that external auditors are still trying their best to pay more attention to cybersecurity-attacked companies on the purpose of supplying the most reliable financial reports of the companies to the public.

Nevertheless, there are still three limitations recognized in this study. The first issue is accounted for the short-reviewed period of time of this research, just ten years from 2005 to 2014 due to the difficulties in approaching latest financial data supported for the regression model. If the period of time can be extended longer up to date, the research will provide a clearer picture about the relationship between external auditors' concern and cyber criminals. Secondly, there are missing financial data for some companies which then leads to the reduction of some controlling variables compared to the original model in Rosati et al.'s research [31] and the insignificance of three controlling variables. The reduction in the number of the controlling variables did not affect the significance of the model, the inclusion of the industry sector (SIC) and the YEAR controlling variables slightly increased the explanatory size of the model. The inclusion of the business sector and the year improved the model and proved that industrial sectors need to be analysed separately and be compared in the light of cyber-attacks in the future. Based on these limitations, further research can be conducted with longer and latest examined period of time and the full collection of financial data to support for the regression model.

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SOCIETAL VULNERABILITY TO ELECTRICITY SUPPLY FAILURE

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ABSTRACT

Today's modern society depends on a number of infrastructures to operate. Failures in these systems cause significant economic impacts and can also endanger the lives and health of the population. The high importance of these infrastructures has led them to increasing attention in recent years and are referred to as critical infrastructure. Critical infrastructure in the energy sector is considered to be one of the most important infrastructure networks significantly entering into ensuring the functional continuity of the society. Its importance is also perceived in terms of interconnections and correlations with other critical infrastructure sectors as well as in terms of electricity interconnectivity in Europe, as in the interconnected European system the effects are spreading across systems of all single country transmission system operators very quickly. For these reasons, the European Union considers this sector to be strategic and of European importance.

The aim of the article is to clarify the primary causes of disruption of large-scale electricity supply and their impact on the functioning of society, focusing on the vulnerability of urbanized large settlements - urban agglomerations in the event of long-lasting blackout disturbances. It contains a presentation of the importance of electricity for society, definition and analysis of the causes of disruption of large-scale electricity supply continuity, consequences of large-scale blackout on community functioning and its basic functions and current knowledge on vulnerability of large urban agglomerations to long-term disruption of electricity supply and possible solutions.

KEY WORDS

electricity infrastructure, disruption of large-scale, blackout, society, vulnerability

CLASSIFICATION

JEL: K32, O13, Q40

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INTRODUCTION

Modern society and sustainable technological progress are increasingly dependent on a continuous and reliable supply of electricity. Electricity supply is key to the basic needs and functioning of human society. If the supply of electricity is interrupted or significantly reduced, there is a risk of a reduction in economic and social activities, a threat to property, but often also to human health and life.

The electricity sector is of irreplaceable strategic importance in every society and, as it is necessary for the safe and reliable operation of other vital infrastructure, it is included among the key sectors of critical infrastructure. Critical infrastructure is an asset, system or part thereof that is necessary to maintain the basic functions of society, health, protection, security, quality of life of the population from an economic and social point of view, and whose disruption or destruction would have serious consequences for not being able to maintain these functions [1].

A specific feature of the electricity infrastructure is the fact that in the event of its disruption and subsequent interruption of electricity supply, the impacts on the external environment of the electricity system may be much higher and more unfavorable than the equipment damage itself or losses from loss of revenue for undelivered energy. This fact is reinforced by the interconnections and correlations of the electricity sector with other sectors of critical infrastructure, as well as other sectors. Electricity systems in Europe form a complex system and possible disruption or damage to interconnected energy networks can affect a large number of people, endanger their health and lives, cause an adverse environmental impact and cascade effect of the interconnected systems.

CAUSES OF LARGE-SCALE ELECTRICITY SUPPLY DISRUPTION

Disruption of large-scale electricity supply occurs in the case of a significant and sudden shortage of electricity or endangering the integrity of the electricity system, its security and the reliability of operation throughout the country, the defined territory or part of it [2]. If the whole electricity system or a significant part of it finds itself without voltage, there is a negative event called blackout. On a practical level, blackout represents a large-scale disruption of electricity supply to a large number of customers over a period of time.

European legislation according to EU Regulation 2017/1485 defines blackout as the state of the electricity system when all or part of the transmission system is out of operation. A blackout failure occurs if at least one of the following criteria is met:

- 1.) loss of more than 50 % of demand in the concerned Transmission System Operator's control area,
- 2.) total absence of voltage for at least three minutes in the concerned Transmission System Operator's control area, leading to the triggering of restoration plans [3].

The primary causes of disruption of large-scale electricity supply are failures of any of the subsystems of the electricity infrastructure, which consist of:

- energy sources (power plants),
- transmission and distribution systems,
- controller information and control systems,

Power plants may be out of operation mainly due to [2]:

- direct damage to certain manufacturing equipment (due to technical failure, material error, neglect of maintenance, natural disaster, intentional attack,...),
- malfunction of the control system,

- improper controller action or manipulation (failure of a human factor),
- disintegration of the electricity grid supplied by the power plant,
- lack of fuel or other operating materials.

Transmission and distribution systems are particularly vulnerable to [2]:

- direct damage to a certain line element,
- malfunction of the control system or the automatic protections,
- improper controller action or incorrect handling,
- malfunction of technology, damage, failure of human factor,
- an imbalance between supply and demand in the system exceeding a certain threshold etc.

Controller information and control systems are forced to interrupt their function due to [2]:

- direct damage to certain elements of the system,
- incorrect function of system elements – data distortion, incorrect data evaluation, deficiencies in SW equipment, etc.,
- failure of the human factor,
- intentional overloading of the system,
- external attack – cyber attack and many others.

The transmission system of the Slovak Republic is dimensioned so that it is able to handle the failure of any one critical element, so that a simple failure is relatively easily eliminated. Thus, a large outage of the volume of transmitted electricity due to the collapse of the power system usually occurs with the synergy of several causes, acting at the same time. A frequent cause of cascading power outages is natural factors, such as strong storms, extreme winds, landslides, icing on power lines, forest fires, etc. A significant threat to the electricity system is also the human factor – intentional/unintentional activity resulting in a negative event, as well as wrong decisions in the operating the system.

In the conditions of the Slovak Republic, outages in the supply of electricity occur rather sporadically, especially during storms, snow calamities, floods or accidents on the transmission system or during its local overload. However, it can be argued that many serious outages were prevented mainly due to the robust and well-dimensioned transmission system.

IMPACTS OF LARGE-SCALE ELECTRICITY SUPPLY DISRUPTIONS ON SOCIETY

If various preventive or operational interventions fail to prevent the interruption of electricity supply, a failure occurs. Critical infrastructure entities that necessarily need electricity for operation are usually equipped with spare sources (generators, backup sources, etc.).

However, back-up electricity sources will be kept in operation by critical infrastructure operators for only a few hours. The situation becomes critical if there is a long-term outage.

The magnitude and extent of the effect and impacts of the power outage in the affected area depend on several basic factors [4], as shown in Figure 1.

Disruption of large-scale electricity supply causes the emergence and development of a crisis situation – a state of emergency – not only among consumers, but also a threat to the protected interests of the state. The effects of blackout on the critical infrastructure sectors and other sectors of the economy may be as follows:

Industry – termination of operations in industrial enterprises can cause serious paralysis of the national economy with significant economic losses.

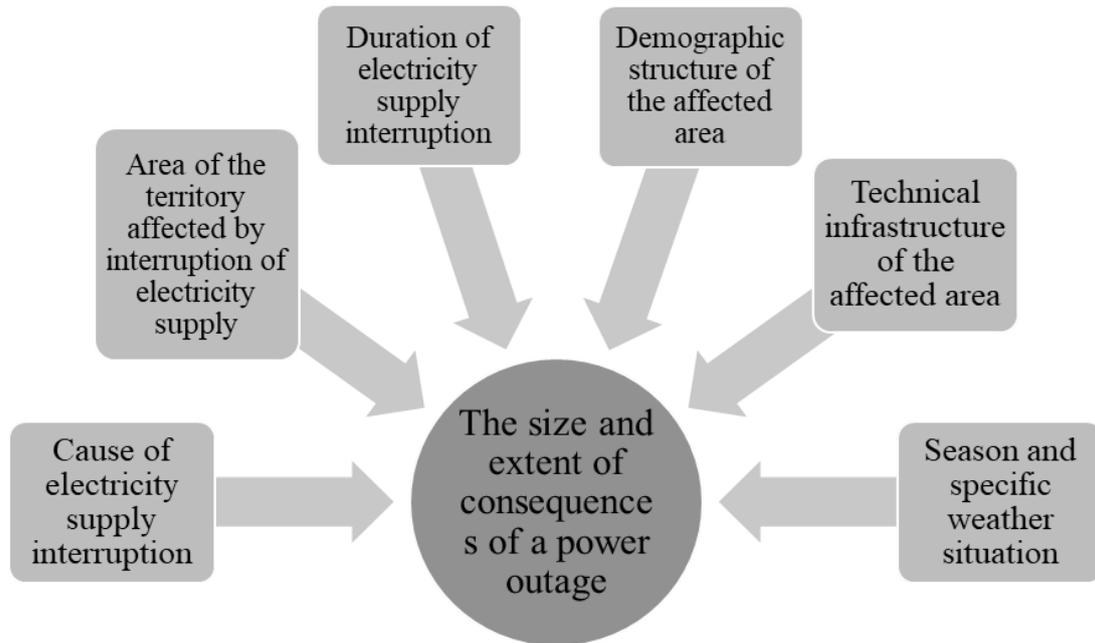


Figure 1. Factors influencing the magnitude and extent of the consequences of a power outage.

Gas industry – interruption of natural gas transmission and distribution due to a malfunction of technical equipment dependent on electricity.

Oil and petroleum products – malfunction of pumping equipment, termination of oil transportation and production of petroleum products, limited fuel stocks.

Communication and information systems – total failure of all ICT systems depending on the size of the capacity of stand-by power supply system.

Transport – malfunction of traffic lights and electrical interlocking devices, malfunction of petrol stations, standing electric traction vehicles, standing underground metro system, significantly limited railway transport, stopped air traffic [5].

Water and atmosphere – malfunction of drinking water treatment equipment, malfunction of pumps, paralyzed function of releasing water from tanks, regulation of water flow in rivers, wastewater treatment and sewerage, non-functional meteorological service.

Healthcare – only basic outpatient care will be provided by general practitioners without the possibility of using any devices dependent on electricity (diagnostic devices), limited operation of hospitals and hospital facilities, limited capacity of stand-by power supply systems, termination of production of medicines and medical supplies, etc.

Public administration – a significant reduction of most functions, e.g. payment of social benefits and pensions, possible problems in prisons, in the judiciary. Crisis departments of state administration and self-government should be prepared for a full function in the given conditions [6].

Banking and financial sector – impossibility to make payments, cash points malfunction.

Post – malfunction of technical devices dependent on electricity, e.g. sorting facilities, termination of postal services.

Food and agriculture – lack of some foods e.g. due to non-functional mills, bakeries, slaughterhouses, meat and poultry processing plants, reduced milk production, termination of ventilation systems in large farms, termination of refrigeration and freezing equipment.

Emergency survival of the population – includes measures for emergency supplies and emergency accommodation. Emergency supplies will focus on the supply of minimum meals, minimum doses of drinking water and the provision of other basic needs to persons affected by an emergency, e.g. heat supply and basic health care [7].

The effects of the long-term blackout on individual sectors of the economy so far have serious social and economic consequences which vary considerably depending on whether they take place in large cities and urban agglomerations or in rural settlements.

Compared to urban settlements, rural settlements are able to ensure a certain energy and food self-sufficiency and survive for a certain period of time with the basic needs provided. In contrast, large urban agglomerations have a specific structure and a higher complexity of institutional and functional links, which make their inhabitants highly vulnerable to power outages. The key factors that make large cities and agglomerations more vulnerable include, in particular, the high concentration of population and the interconnected system of urban critical infrastructure, the disruption of which can cause e.g. lack of water, food, heat and thus cause a widespread state of emergency and later also social unrest destabilizing the standard functioning of institutions and the lives of people in big cities.

VULNERABILITY OF LARGE CITIES IN THE EVENT OF A BLACKOUT FAILURE

The electricity system of the Slovak Republic ranks among the internal systems due to its location in the European energy infrastructure. It is an electrically compact unit connected via the so-called cross – border lines (400 kV and 220 kV) to the electricity systems of most neighboring countries (Poland – 2, The Czech Republic – 5, Hungary – 2, Ukraine – 1) [8].

The basic strategy of system recovery after a blackout failure is also based on this fact – voltage recovery from neighboring transmission systems. This option is preferred by transmission system operators mainly for the purpose of regaining a stable voltage of the order of minutes. If such a possibility is not available, the control centre of the transmission system proceeds according to the standards for ensuring the restoration of power supply from small backup power plants capable of so-called start from darkness.

From the point of view of the topology of the electricity network, the “open-all” strategy is most often used. This means that all switches in the affected area are turned off either automatically or manually. By switching them off, a state is reached in which the controller bases the system renewal solution on clearly defined input conditions. The controller then solves the restart of the power plant units and their continuous loading by gradually connecting other elements of the transmission system. The following priorities are usually respected:

- 1.) own consumption of nuclear power plants,
- 2.) own consumption of system conventional power plants,
- 3.) capital or the most important city of the affected area,
- 4.) other urban and industrial agglomerations,
- 5.) other consumers.

Renewal of the operation of the distribution system is possible only after the renewal of the operability of the transmission system (or its parts). The distribution system operator is responsible for restoring the power supply to the distribution system.

The standard of renewal of electricity distribution after its interruption is to ensure the renewal of supplies to the offtake or handover point of the local distribution system operator within the time limits up to:

- 18 hours in the distribution system network with a voltage level up to 1 kV,
- 12 hours in the distribution system networks with a voltage level above 1 kV [9].

Any power outage (even a short-term one) is registered almost immediately by all persons in the affected area. Such a negative event will have more serious effects in areas with a higher concentration of inhabitants, such as large cities or industrial agglomerations. It is in such densely populated agglomerations that the unavailability of basic services and important operational systems and services with time causes a state of panic and chaotic behaviour and decision-making (Fig. 2).

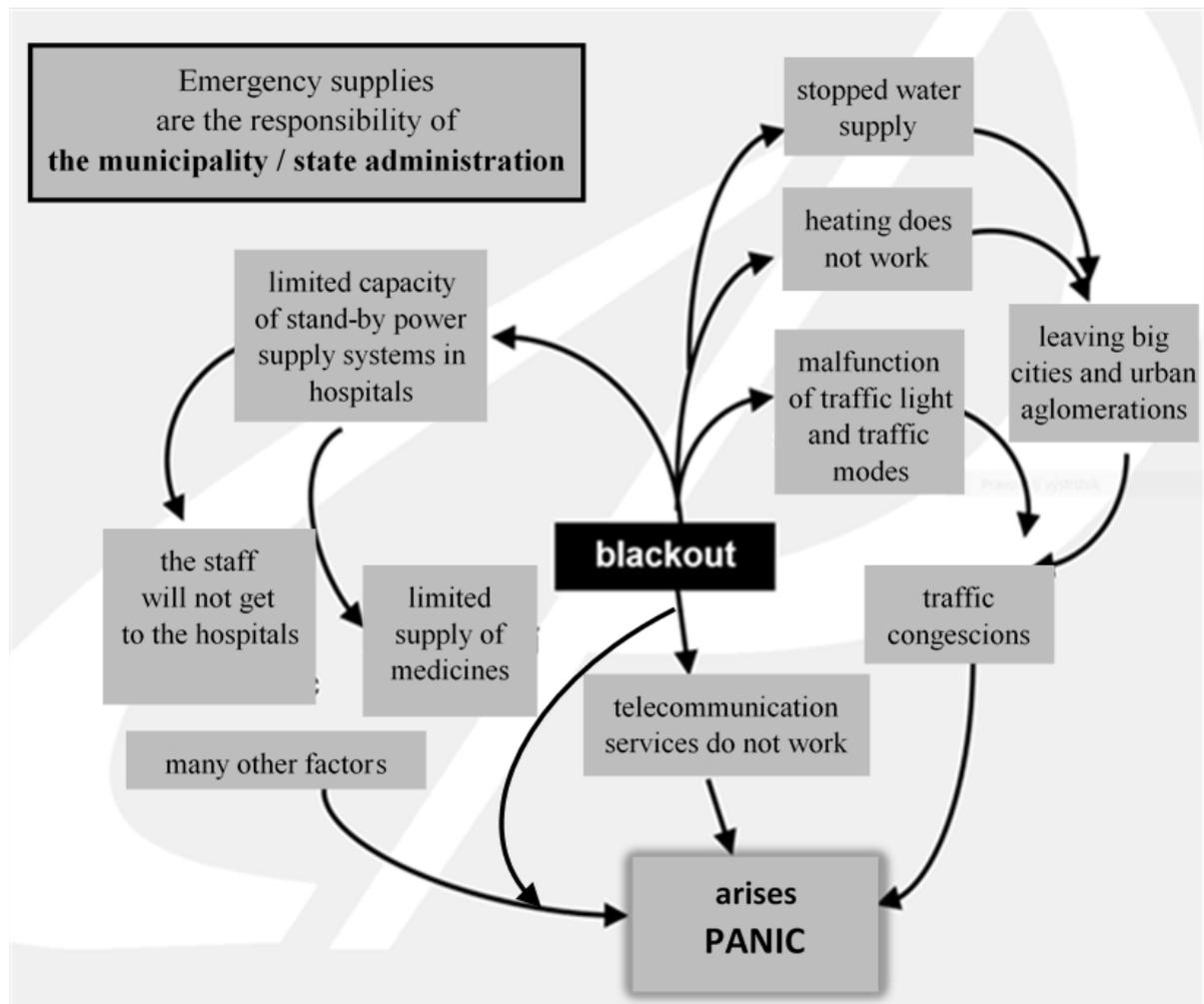


Figure 2. Influence of blackout on basic services and occurrence of panic or chaotic behaviour.

In the event of a blackout failure, it will not be possible to use almost any technology that is directly dependent on the electricity supply and is not simultaneously backed up by alternative energy sources (e.g. diesel generators, batteries, backup UPSs, etc.).

In the first phase of the outage (in the order of seconds, minutes) the following will not work:

- all devices that need to be connected to the electricity network for their operation,
- ordinary lighting (in households, public buildings, street lamps, ...),
- security devices for buildings (electric opening of doors, garage doors, etc.),
- traffic signaling devices (traffic lights, signaling at railway crossings, variable traffic signs, etc.),
- cashpoint machines and at the same time it will not be possible to make purchases in stores with electronic sales records (barcode scanning, card payments, etc.),

- most petrol stations,
- public transport, which is directly dependent on electricity supplies (trains, metro, trams, trolleybuses and others).

In the second phase of the outage (in the order of units of hours) problems will arise in areas such as:

- drinking water supply,
- gas and heat supply,
- signal failures of mobile operators,
- malfunction of data networks (Internet), data centers, etc.,
- waste collection and much more.

In the later stages (order of tens of hours) there will be other serious problems in the area:

- supplies (food, medicines, fuels, etc.),
- communications (limited access to verified information),
- functioning of individual offices and other institutions,
- security (violation of public order, looting, theft, etc.).

In connection with the failure of electricity supply, there will be e.g. people get stuck:

- in lifts (if they are not equipped with special backup sources),
- in public transport (especially trainsets on electrified lines),
- in traffic jams (due to a malfunction of traffic signaling devices).

Other significant impacts of blackout on the operation of the system include:

- restrictions on the availability of information,
- congestion of telephone networks (it will be very difficult to establish contact with close persons),
- overload of emergency lines and unavailability of units of the Integrated Rescue System,
- limited operation of hospitals (performed only urgent operations, etc.),
- limited possibilities to ensure hygienic standards (non-functioning water and waste, perishable food, etc.),
- limited possibility to buy food and water,
- limited purchase of fuel,
- limited possibilities in providing heating,
- increased risk of fires (emergency lighting with candles, etc.),
- impossibility of employment and school attendance (most buildings and production facilities will be closed),
- limited possibility of transport (limited use of public transport, lack of fuel in motor vehicles, etc.)

The limit of the standard of renewal of electricity supply to end consumers (within 18 hours) also corresponds relatively well with the results of EU foreign research projects within the PASR call – Preparatory Action on Security Research [10] After about 18 hours, the situation changes from serious to critical (Fig. 3).

In case of a national blackout, with a typical daily load (not the maximum) of the Slovak electricity system at the level of approximately 9 000 MW, the situation according to Fig. 3 could become catastrophic after about 7 hours after blackout.

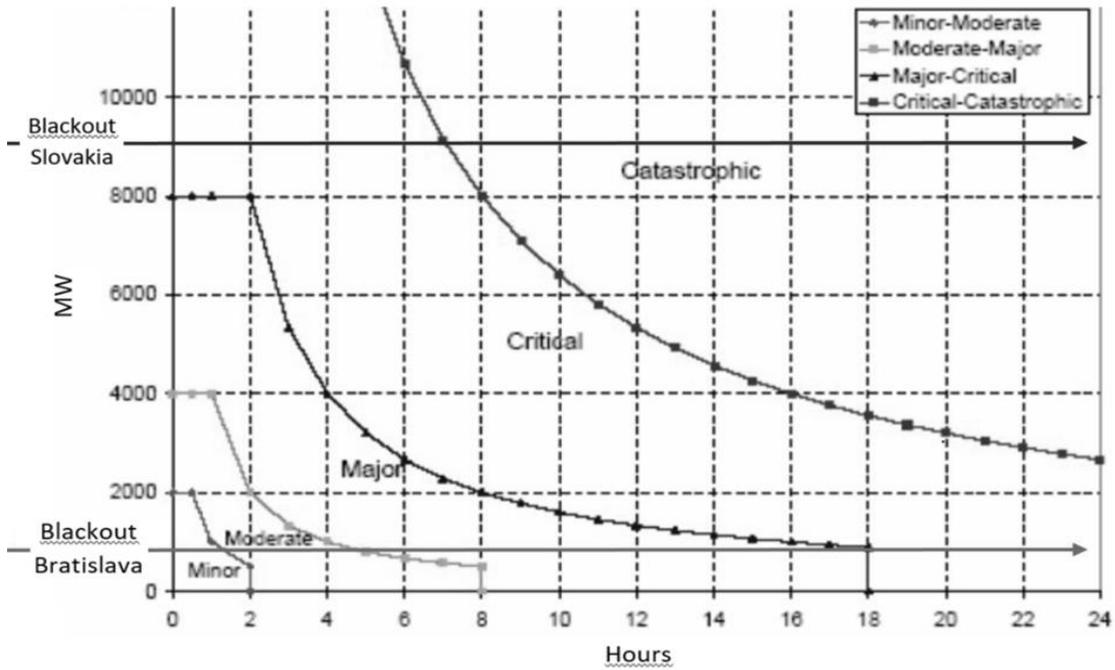


Figure 3. Criticality of the situation depending on the extent and duration of the power failure.

In terms of the reliability of the entire electricity supply chain, the risk management system often addresses the question of where it is appropriate to invest in proactive preventive measures (system backup, island solutions,...) to reduce risk and where it is sufficient to leave mitigation only to the implementation of reactive activities that respond to the occurrence of a crisis event.

The interoperability of crisis management (supplier and municipality) with the risk management process [11] in the area of supply of vital commodities (apart from electricity, also heat, drinking water, natural gas and others) also plays a role in this decision (Fig.4)

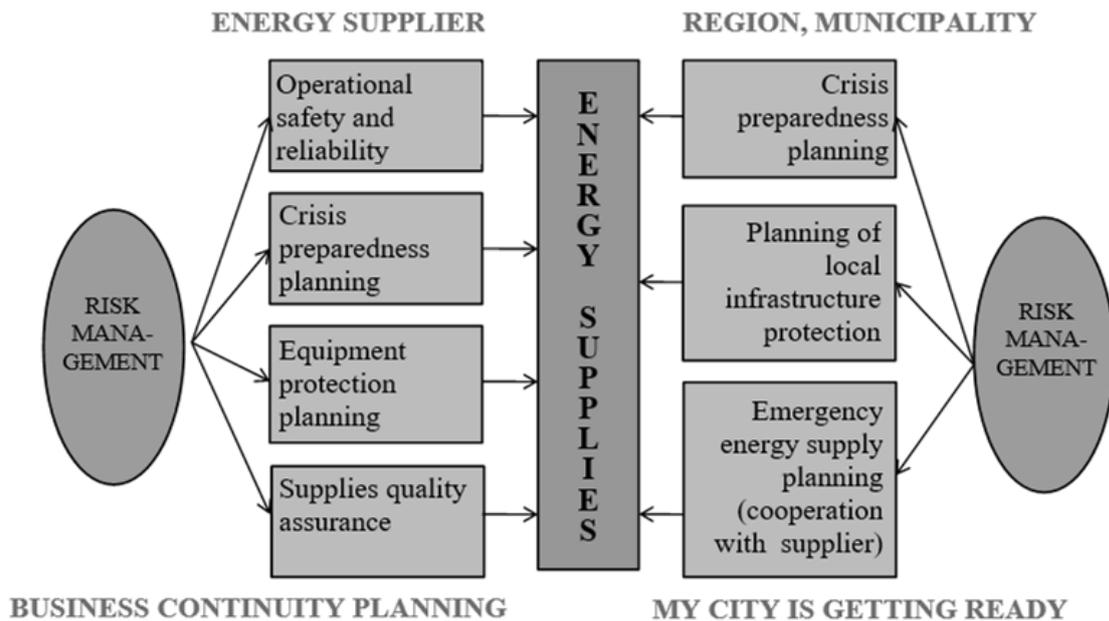


Figure 4. Ensuring interoperability of crisis management and risk management.

Within the recovery plans of transmission or distribution system, in practice it is impossible to predict how a potential outage will develop or predict a point of disruption. A blackout is usually the last phase of a complex event and the result of a series of several events that is almost impossible to define in advance.

The process of recovery of the electricity system is generally based on 3 principles:

- ensuring the ability to “start from the dark” on selected generators (the ability of the power source to go into operation in a situation where the distribution network has lost voltage – in most cases provided by diesel generators),
- voltage recovery in the transmission system using available generators (heating plants, back-up power plants, etc.) or from neighbouring transmission networks, including resynchronization of individual island operations (island operation = part of the electricity system that operates locally and is not connected to the synchronously operating electricity system),
- gradual restoration of power supply in distribution systems and restoration of electricity supply to other customers.

At present, the most preferred preventive and proactive measure against the negative effects of large-scale blackout in large cities is the implementation of the so-called public crisis island operations (CIO) which enable the implementation of emergency electricity supply. The recovery would take place in smaller parts. Relatively small “energy islands” would be created for the supply and distribution of electricity around some power plants or towns, which would be gradually interconnected [12].

Local urban crisis island networks, usually supplied by municipal heating plants, can play an important role in emergency situations in order to safeguard the protected interests of the state or large and important agglomerations. Sources of the distribution system, which are additionally equipped with the so-called black start, in addition to island operation for emergency power supply, can also be used to restore the operation of the electricity system after the blackout, mainly to start and ensure the own consumption of some system power plants. Such a solution should certainly belong to the basic functionality of currently developed and tested intelligent energy networks – the so-called Smart Grids [13, 14].

It is recommended to increase the energy security of large cities according to [12]:

- build control systems and interconnections ensuring island power supply of all agglomerations with more than 50 000 inhabitants,
- implement effective tools to prevent the spread of faults and a controlled transition to island subsystems and ensure an independent ability to start from the dark of individual island solutions,
- in the area of development of distribution systems, to ensure their ability to work in island operations in the medium term in the event of a breakdown of the transmission network and to ensure at least the minimum level of electricity supply required for the population and critical infrastructure,
- ensure the elaboration / updating of territorial energy concepts of self-governing units and large cities (over 50 thousand inhabitants) so that they are aimed at ensuring the functionality and reliability of island operations in emergency situations
- create conditions for the involvement of heating plants in the creation of territorial concepts and the determination of their role in island solutions of a specific area in emergency situations.
- link the content of measures to increase the preparedness and resilience of energy infrastructures of large cities with the content of economic measures for crisis situations [15],

- pay attention to the preparation of alternative variants of the functioning of energy systems so as to ensure at least the most necessary energy supplies to priority customers,
- support the construction of stand-by power supply of electricity,
- work closely with regional government and suppliers of energy commodities,
- support research and innovation in the field of local (island) subsystems and their activities to ensure at least a minimum level of electricity supply to the affected area and to maintain the functionality of local critical infrastructure.

CONCLUSIONS

The increasing number of crisis situations threatening the stability of the operation of the electricity system, natural disasters, but possibly also intentional terrorist attacks, make electricity and related critical infrastructure significantly vulnerable because they can cause the so-called blackout. Energy security is one of the most important factors necessary for maintaining the functions of the state as well as the functions of territorial self-government and the protection of lives, health and property of the population in the full sense of the word.

It has been shown that the biggest threat to community life in large agglomerations is a longer-lasting blackout that can destabilize the functioning and paralyze the basic functions of a city or an important industrial agglomeration. In the event of a prolonged power outage, it is not possible to meet basic physiological needs, such as heat, water and food, nor is it possible to sufficiently maintain public order. However, if the distribution networks in larger cities will be able to work in the so-called emergency island operations powered by e.g. from municipal heating plants, the overall negative impact of blackout on the affected area and its functions will be significantly reduced.

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MODEL OF ASSOCIATED HOSPITALITY: DIFFUSE AND INTEGRAL HOTEL IN THE REPUBLIC OF CROATIA

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ABSTRACT

Diffuse hotels represent a model of associated destination hospitality in the function of revitalizing villages and small towns in rural areas by putting in the tourist function existing facilities/buildings that have the status of traditional construction and ambient architecture. The aim is to popularize the historical core and the concerned area through tourist services, i.e. to encourage the development of authentic tourist services and, at the same time, to preserve and popularize traditional culture and generate revenue/income throughout the community, i.e. to encourage new value. Due to the specificity of the tourist offer in the Republic of Croatia, a model of integral hospitality has been developed in the function of the association of existing bidders. Both models are recognized in Croatian legislation. This article analyzes the characteristics of the model of diffuse and integral hotels, special attention is paid to the presentation and critical analysis of the existing Croatian legislation, and provides guidelines/suggestions for its improvement. The research problem of this article consists in the analysis of limiting factors in the business connection of the private sector through the diffuse hotel model. The key innovations and contribution of this article in the research of the business model of a diffuse hotel in Croatia are reflected in concrete proposals for improving the organization of diffuse hotels, improving existing legislation and strengthening the competitive strength of Croatian tourism by encouraging authentic destination tourism products.

KEY WORDS

associated hospitality, diffuse hotel, integral hotel, Republic of Croatia, Croatian legislation, guidelines

CLASSIFICATION

JEL: Z32, Z38, Z39

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INTRODUCTION

To this article, the theme of diffuse and integral hotels in the Republic of Croatia has not been adequately researched or given adequate scientific and professional attention. Since diffuse and integral hotels are formed following the acceptance of legal regulation, this article focuses on the definition of the diffuse and integral hotel model in general, and the analysis of existing legislation in the Republic of Croatia, its advantages and disadvantages. Based on the analyses, guidelines for improving legislation have been proposed so that it can be used in the best possible way in establishing diffuse and integral hotels as new models of association, enhancing competitiveness and fostering sustainable development. This article does not describe the existing diffuse and integral hotels in the Republic of Croatia, nor has their quality analyzed, because the analysis of the condition and quality standards of these hotels, i.e. analysis of examples of good practice of diffuse and integral hospitality are topics for separate research. The aim of this article is to allocate, describe and interpret the most important characteristics of the diffuse and integral hotel, their structural characteristics, and to analyze the legislative framework for the development of this new form of tourist accommodation in the Republic of Croatia.

For the purpose of research for this article in the process of data collection, various qualitative methods were used, mainly from secondary sources. The following relevant secondary sources were used: scientific and professional papers, books, Croatian legislation, official gazette, websites, official government sites and other sources. The processing of this data was based on description, linking, comparisons, analysis and interpretation. The limited amount of available data is the main reason why a descriptive research method was used in this article.

Before discussing the topic itself, the relevant foreign and Croatian literature on the problem was presented and analyzed. The main part of the article includes the definition of a diffuse hotel, its organizational framework, characteristics, special features and innovations. The diffuse hotel is also presented as a model for the development of new values, and a special chapter is dedicated to the analysis of Croatian legislation applicable in the examples of diffuse and integral hotel, with special elaboration of their role in strengthening the competitiveness of Croatian tourism. An important part of the article refers to the interpretation of proposals for improving the organization and operation of diffuse and integral hotels in Republic of Croatia, while the conclusion summarizes the importance of this research for Croatian science, paper originality and contributions / importance for future research on diffuse and integral hotels in general.

The scientific contribution of this article is that it provides a relevant and well-founded view on the definition of diffuse and integral hotels in general, and especially in the Republic of Croatia with regard to the existing legislation for which guidelines for its improvement are proposed. This article represents a step in further scientific research of diffuse and integral hotels in the Republic of Croatia, as well as specific problems related to the adoption of strategic decisions between the makers of tourist legislation and the real, private sector who are operationally involved in creating offers of diffuse and integral hotels. As the topic of diffuse and integral hotel has not been adequately researched in the Croatian scientific literature, this article represents a further step in filling this gap.

The main thesis of this article is based on the analysis of structural specifics of the diffuse hotel model, its supply characteristics as well as the analysis of innovative approach in coordination and better market connection of the private sector in tourism through improving the existing Croatian tourism legislation.

The actuality of the research problem of this article is based on changes in global tourism trends. Tourist trends result in a specific tourist demand based on authentic tourist products and services, which a diffuse hotel is in its essence. Also, trends favor alternative tourism as opposed to mass tourism, i.e. the valorization of the cultural specifics of the destination with a responsible approach in the development of tourist services. In this sense, diffuse hotel represents a sustainable way of managing and developing a tourist destination.

LITERATURE OVERVIEW

This brief review of the literature will list and present selected foreign and domestic scientific literature that has a diffuse (and integral) hotel as its topic, and is important for its understanding, and one of its numbers has been used in writing this manuscript. The research of recent literature is limited, first of all, by its limited quantity, i.e. number. This numerically limited literature, most of which is scientific research (studies), is geographically limited mainly to Italy, then to Slovenia and a smaller number of papers related to Croatia.

A study of the literature on the diffuse hotel revealed that one of its numbers refers to different approaches of researchers and practitioners on the interpretation, i.e. different use of the term “diffuse hotel”, i.e. “Albergo Diffuso”, when it is translated from Italian into English [1; pp.44-45].

“Diffuse Hotel”, or “Albergo Diffuso”, has Italian origin [2], and represents a relatively new theme of scientific research [3, 4]. The occurrence and development of the diffuse and integral hotel was described by C. Vallone and V. Veglio in a brief overview, specifically referring to their characteristics and importance [5]. The theme of the diffuse hotel, in many of his works, was studied by Dall’Ara, who systematically dealt with various aspects of this model of associated hospitality, for example by defining, the reasons and needs of the establishment of a diffuse hotel in an area [6], then purposefulness, values, conditions that must be met by the accommodation facilities of a single diffuse hotel, and various marketing approaches [7, 8]. The development of the concept of an integral hotel as a form of innovative tourism, initially a mountainous area in Italy, with an analysis of all its comparative features opposite other forms of tourist offer accommodation, was the theme of the scientific work of F. Colbert [9]. How important a diffuse hotel is for the development of sustainable tourism, especially since it is sensitive in preserving cultural heritage using the material and intangible heritage sources of the area, was studied by C. Vignali [10]. The diffuse hotel was also discussed as a business tourism model dominated by user demands for quality with great importance of the location, i.e. landscape; all this can encourage the development of new economic and social values, while the case study, i.e. the good practice of the “Chateau Le Cagnard Hotel” was used as a sample example [11].

Some researchers dealt with certain specifics of diffuse hotels. One such study confirmed that the diffuse hotel is a socio-culturally embedded entity in the place where it occurs and that the owners of the diffuse hotel, i.e. entrepreneurs, have a high level of personal motivation in the establishment of one such hotel [3; pp.235-236]. The second research, on the other hand, defines the characteristics of the business model of the diffuse hotel in terms of understanding the key elements of the basis of the hospitality approach, which are business idea, value creation and innovation [12]. The business idea aims to revitalize the place through the emotional connection between the place and the entrepreneurs. In terms of value creation, a diffuse hotel is a form of accommodation that offers more than a hotel experience; tourist can live as a resident and experience local traditions and culture. Innovation refers to services that are completely different from traditional hotels. D. Throsby tried to show that the diffuse hotel model can be interpreted as a means of combining economic and cultural values into a

single framework with the concept of “culturally sustainable development”, which he defines as a set of criteria relating to the improvement of tangible and intangible well-being, intergenerational and within generational fairness, and recognition of inter-dependency between them [13].

Some scientific papers analyze the diffuse hotel model in certain areas and/or on certain specific examples and try to find answers to questions on how to overcome excessive tourism [14], in some, the Italian diffuse hotel model is considered as the best possible way to preserve traditional heritage and encourage development under similar conditions in other European countries [15], or analyze the services and user satisfaction of diffuse hotels in order to justify the necessity of such an innovative entrepreneurial model [16].

In the Slovenian scientific literature, we highlight the paper of S. Zupan Korže [1]. In it, the author interprets the key characteristics, structural and legislative features of a diffuse hotel as implemented in Italy, which he compares with a traditional hotel, and presents the first Slovenian diffuse hotel, its legal and organizational structure. The results of the author’s research showed that a diffuse hotel in Italy is formally considered a subtype of hotels with strong connections to the surrounding area and local culture and with special physical characteristics and hospitality service that distinguish a diffuse hotel from traditional hotels and other traditional types of tourist accommodation. As for Slovenia, the author states that the initiative to design diffuse hotels was founded in 2010, but only one was implemented, in Konjice, in December 2017, despite the gap between the strategic approach of Slovenian tourism policy makers and the private tourism sector. It is interesting that Zupan Korže in his research cites and consults the Croatian “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels” [17], stating that in Croatian legislation the term “diffuse hotel” is used as an official name, i.e. translation of the term “Albergo Diffuso” [1; p.44].

Croatian scientific literature is modest when it comes to exploring the topic of diffuse and integral hotel. Several scientific papers discuss the use of the appropriate Croatian name, i.e. the translation “Albergo Diffuso” as “diffuse hotels” [18], i.e. the use of the original Italian name [19; pp.608-609]. In some Croatian scientific papers “Albergo Diffuso” is understood as a tourist/hospitality model – a form of innovative tourist content and innovation [18], i.e. as a hospitality concept [20].

One of the first more extensive scientific papers that deals with the theme “Albergo Diffuso” is that of M. Dropulić, A. Krajnović and P. Ružić [19]. In it, they represent “Albergo Diffuso”, until then unknown in Croatian theory and practice, as a new type accommodation that additionally makes maximum use of the cultural and historical heritage of the destination with the aim of developing sustainable destination tourism. They are also trying to answer questions about the risks of investing in such a model of accommodation, its possible impact on the development of rural areas, examining the relationship to standard hotels and the ratios of quality and price in such a hotel. The authors conclude that “Albergo Diffuso” is one of the possible solutions for the sustainable growth of tourism, and its characteristics are very interesting and in marketing terms an attractive form of tourist offer. Also, the authors prove that Croatia has great potential for the development of the concept of “Albergo Diffuso” in tourism legislation, tourism system and entrepreneurial practice. The development of this concept would have a positive impact on the overall competitiveness of the Croatian tourist product, and at the same time would increase the quality of tourist destinations in rural areas, where the concept would be developed. In addition, the opportunities for family entrepreneurship in the hotel industry would increase. Influencing the preservation of the centers of historic cities that are full of Istria and Croatia, the concept of “Albergo Diffuso”

has a significant impact on preserving the rich Croatian cultural heritage, as well as the maximum use of Croatian traditions and authentic way of life, while offering a new type of tourist offer showing the characteristics of the concept of sustainable tourism growth. Through research into the possibility of transforming the existing family hotel “Kaštel” in Motovun into the first “Albergo Diffuso” in Croatia, the authors confirm the thesis that this concept in Croatia is a possible, necessary and important factor in responsible tourism growth in Croatian rural areas. One of the basic preconditions for achieving this goal is the application of the concept of “Albergo Diffuso” in all segments of the tourism system, from legislation to entrepreneurial practice, which will be possible by participating in EU projects dealing with rural development [19].

It also highlights a scientific paper that analyzes some specific features of diffuse hotels and explores the possibility of improving the tourist offer of agricultural households on the basis of the application of diffuse hotels in the area of Dubrovnik-Neretva County, which has shown that the diffuse hotel can be considered and accepted as a form of accommodation in the future development of tourism in the area of the mentioned county [21]. Furthermore, in the article of S. Tišma, A. Farkaš and A. Pisarović, the authors present the possibility of applying the model “Albergo Diffuso” in the area of three inhabited Elaphite islands – Koločep, Lopud and Šipán in Croatia [22]. Their research showed that the Elaphite Islands have most of the necessary prerequisites for the implementation of the “Albergo Diffuso” model: a rich but underused natural, historical and cultural heritage, a reasonable number of accommodation capacities and a long tourist tradition. The article summarizes the solutions and suggestions of a list of improvements to extend the tourist season and attract wider groups of tourists. The successful application of the “Albergo Diffuso” model would inevitably require changes to the existing system in the sense that systematic and coordinated cooperation must be established between relevant stakeholders at all levels of governance [22; p.107].

Of importance is the research of J. Đurkin and M. Kolarić, who in their scientific work gave a systematic overview of the main characteristics, management practices and organizational forms associated with diffuse and integral hotels with emphasis on their benefits in terms of sustainable tourism and local community development [23]. Their analysis provides new insights into important differences between the planned positive changes intended to introduce diffuse and integral hotel models into Croatian practice, their recognition and interpretation in the real tourist sector, based on which recommendations for future development and management of diffuse hotels are proposed.

At the end of this review of the Croatian scientific literature, we highlight two strategic documents. One is the “Strategy for the development of Croatian tourism by 2020” which defines and emphasizes the importance of accommodation that is applicable for the development of a diffuse and integral hotel [24], and the “National Program for improvement of vacation rentals”, which provides detailed guidelines and activities to enable the transformation of vacation rentals capacities into a diffuse hotel [25].

The main reason for the legal definition of a diffuse and integral hotel in the Republic of Croatia derives from the goals of the “Strategy for the development of Croatian tourism by 2020” which relate to the program of improving vacation rentals. The “Strategy for the development of Croatian tourism by 2020” defines the importance of vacation rentals for the Republic of Croatia and points to the need to raise the overall level of quality of vacation rentals, create preconditions for converting part of the capacity into various forms of collective accommodation (business association) and slow down the expansion of vacation rentals, i.e. the existing share of the accommodation structure of the Republic of Croatia [24; pp.50-51].

DISCUSSION

DEFINITION OF THE DIFFUSE HOTEL

A diffuse hotel can be defined as a popular, tourist-integrated service that includes services such as reservations, reception, accommodation, restaurant, local cooking courses, old craft schools, swimming, hiking and other services [16; pp.247-248]. In a diffuse hotel, the innovation is reflected in the re-use of existing facilities and the involvement of various actors guided by the goal of providing an integrated service [16; pp.248-250]. This is why a diffuse hotel is a good example of the concept of sustainable development [13]. The diffuse hotel concept can revitalize abandoned areas and has the ability to be an innovative business model that suits the environment and cultural interest [5]. Furthermore, the concept of a diffuse hotel protects the cultural landscape, the environment and the community. It also enables the economic development of small rural destinations while preventing depopulation [2]. The development of a diffuse hotel is based on local resources, preservation of the territory, its biodiversity, resource efficiency and energy savings. The importance of preserving and strengthening local identity is also taken into account [26]. The diffuse hotel concept does not require greenfield investment or any other type of construction. It is aimed at using what already exists in terms of increasing the value of tradition and obtaining positive economic results in the context of sustainable development [19].

ORGANIZATIONAL FRAMEWORK

A diffuse hotel consists of structural elements that do not differ in content from a classic hotel, but conceptually are fundamentally different due to the destination approach in organizing services and, in general, the offer. According to the International Association of Diffuse Hotels, Associazione Internazionale Alberghi Diffusi, ADI, the structural elements of a diffuse hotel are [27, 28]:

1.) **Facilities** (buildings) characterized by:

- architectural recognizability,
- architectural (ambient) typicality, and
- their quality maintenance.

2.) **Ambience** (accommodation and common areas) which must be marked by:

- comfort,
- quality arrangement and maintenance of common areas (central reception, living room and other),
- home atmosphere,
- central reception,
- living room (separate space or within the reception), and
- quality of accommodation units (rooms, apartments, houses), a minimum of seven accommodation units connected to an integral hotel located at a distance of approximately 200 meters from the central reception.

3.) **Management structure:**

- entrepreneurial management (professional form of registration of an integral hotel),
- unified management of tourist services through hotel form, and
- competence and professionalism of the employees of the central reception (knowledge of the principles of functioning and organization of the integral hotel).

4.) **Restaurant services:**

- contract with existing restaurants in the place according to the model of business connection to a hotel or an integral hotel organizes its own restaurant as a common space for guests.

5.) **Other (additional) services:**

- managing guests' free time, and
- creating a package of tourist services in order to make the stay of guests in the hotel more meaningful.

The peculiarity of the diffuse hotel, as its name suggests, is reflected in its organization in which accommodation units and other points of tourist services are dispersed by destination, i.e. the historic center of the place, and is characteristic of the historic cores. The basic idea of the diffuse hotel is to put into operation the already existing buildings within the historic center, which are given new value through tourist services, and to connect the already existing accommodation offer known as vacation rentals. At the same time, the construction of new facilities that could disrupt the authentic environment is prevented. The goal of organizing this type of hotel is to popularize historical cores through tourist services, i.e. to encourage the development of authentic tourist services, and at the same time to preserve and popularize traditional culture and generate income/revenue in the whole community, i.e. to encourage new value through a new tourist product. Diffuse hotel is presented as a model of sustainable development which aims to use existing resources, tangible heritage (culture, crafts, small business) and intangible (traditions, knowledge, social components) of a place or territory.

Sustainable tourism is one of the European Commission's priorities where the diffuse hospitality model can be used as a sustainable development strategy, as it meets several goals in the community, such as:

- ***economic prosperity***: the diffuse hotel is a model focused on revitalizing and restoring existing resources and creating new values,
- ***capital and social cohesion***: a diffuse hotel improves the quality of life of the local community and offers visitors experiential experiences through tourist services, reduces the degradation of the natural and cultural environment and opens up opportunities for the domestic population for entrepreneurial enterprises through tourism services, and
- ***high potential for business growth, development and the creation of new jobs in the community***: directly, by employment in a diffuse hotel, and indirectly, by developing partner entrepreneurship in the community for the purposes of diffuse hotel services [29; p.4].

The diffuse hotel is an innovative form of sustainable tourism for present and future generations because it promotes heritage and is oriented towards the revitalization and reinterpretation of local cultural identity and the design of events thematically related to cultural heritage.

CHARACTERISTICS, SPECIAL FEATURES AND INNOVATION OF A DIFFUSE HOTEL

The diffuse hotel is an original model of hospitality that is characterized by a deep connection to the territory and local culture. Namely, as territory and culture are an integral part of the services on offer, the diffuse hotel is conceived as a model of sustainable development, which seeks to recognize the value of local resources such as cultural heritage, small craftsmanship and small entrepreneurship. Local tradition, history and social interaction are also taken into account [8].

Diffuse hotel in historic cores, where the biggest problem is depopulation and abandonment of buildings as a place of permanent residence, can prevent depopulation and abandonment of places rich in history and art, and through tourist services give historic buildings a new

function, creating new added value to the population and, ultimately, the community. The diffuse hotel also promotes the economic development of the historical cores of the place/site, and aims to increase local employment without adversely affecting the environment in terms of contamination of local culture and/or identity.

The diffuse hotel is an integrated system of offering tourist services related to the local community, aimed at a new generation of tourists eager to experience local culture and directly participate in local traditions and other events. The model is based on the following requirements:

- unitary management through professional management of private accommodation connected to the hotel (integrated professional management),
- accommodation units organized in several buildings in the immediate vicinity (within a radius of about 200 m) in the center of the place that are part of the cultural identity of the community (historic buildings),
- the presence of local crafts, and
- the presence of a living community.

The innovation of a diffuse hotel is reflected in the inclusion and connection of different stakeholders who, through coordinated management, develop an innovative form of tourist services (hospitality) by valorizing the potentials in the area where the hotel is formed. Despite having different owners (different stakeholders business-connected in a diffuse hotel), unified diffuse hotel management promotes integrated service and integrated customer service.

The peculiarities and differences between a traditional hotel and a diffuse hotel are obvious. Basically, a diffuse hotel has a clear, conventional hotel structure, given the organization of standardized services provided to its guests, regardless of the fact that the accommodation units are located in different buildings. However, a significant difference is reflected in the way existing accommodation services are managed in historic cores in order to be more purposeful, better and more efficient. That's why the diffuse hotel allows guests to feel part of the community.

According to the business philosophy, a diffuse hotel at the same time represents the home (the idea is that the guest feels intimate as at home in terms of organization of accommodation) and a hotel (since it has all the hotel services that can be available to the guest). As opposite to the diffuse hotel, the integral hotel is characterized as "*Un po' casa, un po' albergo*", i.e. "*Kind of house, kind of hotel*". The characteristics of an integral hotel according to the International Association of Diffuse Hotels, Associazione Internazionale Alberghi Diffusi, ADI, are listed in Table 1 [27; p.8].

Table 1. Characteristics of an integral hotel [27].

INTEGRAL HOTEL CHARACTERISTICS	
Feeling at home	Feeling like a hotel
Politeness and kindness	Providing professional services
Authenticity	Efficiency
Non-standard rooms	Easy booking
Local (traditional) furniture	Price difference – according to the variety of rooms
The importance of detail	Comfort
Connection with the territory	Wide range of services

Communication with the domicile population	Communication with other guests
Informal environment	Privacy

Based on the analysis of the diffuse hotel, it can be concluded that this business model is structured with local characteristics (morphological, climatic, architectural, economic and others), and socio-cultural specific features that have developed in the place throughout history and created a specific recognizable way of life, so-called lifestyle, which is a very strong driver of the development of innovative and integrated, modern, tourism services. The diffuse hotel responds perfectly to the needs of modern tourists, since as a type of hotel it is designed to provide guests with a unique experience of experiencing the historic core/center of the place and to provide a sense of local.

DIFFUSE HOTEL AS A MODEL OF DEVELOPMENT OF NEW VALUES

A diffuse hotel occurs when the following conditions are met [8]:

- an idea launched within the local community and residents who have noticed the benefits that can lead to innovation,
- there is an interest of local stakeholders for joint business operations,
- organization of unified management of services of several stakeholders of different registrations (private renters, restaurateurs, other service providers),
- accepting the risk of a business venture,
- a minimum of seven stakeholders connected in the business model of an integral hotel located at a distance of about 200 meters from each other,
- long-term business through a diffuse hotel model (minimum three years),
- the existence of a developed infrastructure that the guest can use (food stores, cafes, pharmacies, etc.),
- the existence of attractions such as the village, sea, mountains, cultural monuments, archaeological sites, museums and the like, and
- a living community, that is, a town or place that has not been abandoned and inhabited by its inhabitants.

The strengths of a diffuse hotel are:

- **ability to meet the needs of demanding guests with extensive travel experience:** these are tourists who travel very often, who have used their vacation and stay in different types of hotels and different destinations and are looking for innovative tourism products that can reflect the “spirit of the place” (*genius loci*),
- **respect for the cultural ambience:** since the diffuse hotel is organized in already existing facilities within the historical core, it does not intervene in the existing, determined cultural environment but adapts to specifics, and yet acts as a business activity,
- **authenticity:** unlike classic hotels, a diffuse hotel allows guests to experience staying in historic houses and buildings designed to look like home (visually and sensibly),
- **articulated offer:** the guest of the integral hotel has at his disposal a wide range of additional services by the hotel itself, i.e. providers who are business related to the hotel. Also, accommodation is organized in different buildings, at different locations in the historical core, which have different architectural characteristics, different approach to landscaping, and therefore emphasized price differentiation,
- **originality:** original ambience that requires access to the creation of original tourist services which enables better market visibility and market positioning,

- **hotel services:** a diffuse hotel has all forms of hotel accommodation and services regardless of the dispersion of accommodation and other reception services (such as, for example, restaurants), and
- **management method:** a high degree of cooperation of diffuse hotel stakeholders with the aim of creating a unique management structure that performs a large part of the work for stakeholders in receiving guests and organizing additional services.

The critical success factors of the diffuse hotel development model are [27; pp.6-7]:

- integrated tourist services,
- effective management,
- ability to establish relationships between stakeholders providing tourism services and other services of interest to the tourism industry,
- added value to local events (festivals, manifestations, celebrations, etc.) that spread and strengthen local traditions and culture,
- high quality of services,
- preservation of local culture,
- live historical core atmosphere
- supply of locally produced products, and
- the preservation of an authentic environment.

DIFFUSE AND INTEGRAL HOTEL IN CROATIAN LEGISLATION

The main reason for the legal definition of a diffuse and integral hotels in the Republic of Croatia derives from the goals of the “Strategy for the development of Croatian tourism by 2020” which relate to the program of improving vacation rentals. The “Strategy for the development of Croatian tourism by 2020” defines the importance of vacation rentals for the Republic of Croatia and points to the need to raise the overall level of quality of vacation rentals, create preconditions for converting part of the capacity into various forms of collective accommodation (business association) and slowing down the expansion of vacation rentals, i.e. retaining the existing share in the accommodation structure of the Republic of Croatia [24].

Since 2014, the model of dispersed (horizontal) hospitality has been legally recognized in the Republic of Croatia. Two variants of organization have been defined, i.e. two models: diffuse hotel and integral hotel.

In the case of a diffuse hotel, the investor is the sole owner of all facilities in which the hotel is organized. “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels, Article 30”, defines a diffuse hotel as follows [17]:

- 1.) *Diffuse hotel is a facility where guests are provided with accommodation and breakfast services.*
- 2.) *The diffuse hotel must be in predominantly old, traditional, historical, rural-urban structures and buildings, decorated and equipped in the traditional way.*
- 3.) *Diffuse hotel is a functional unit consisting of three or more buildings and/or parts of buildings integrated into the local environment and way of life in the area of one settlement. Each building or part of a building must have a separate entrance, horizontal and vertical communications. Buildings and/or parts of hotel buildings may be spread throughout the settlement between buildings of other purposes. Hospitality facilities in which hospitality services are provided can be separated by a public or shared area. Hospitality facilities (reception, accommodation units, facilities for preparing and serving meals, drinks and beverages, etc.) can be accessed directly from the outdoor area.*

In the case of an integral (associated) hotel, a group of local actors (private sector) creates a kind of consortium, i.e. business is connected by creating a special entity (e.g. company, cooperative). “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group of Hotels, Article 38”, defines an integral hotel as follows [17]:

- 1.) *An integral hotel is a facility in which a caterer/restaurateur provides accommodation and breakfast services in common facilities, its hospitality facilities and/or facilities of other caterers/restaurateurs and/or renters, who have previously obtained a solution.*
- 2.) *An integral hotel is a functional unit in three or more buildings and/or parts of buildings in the area of one settlement. Buildings or parts of hotel buildings can be spread throughout the settlement between buildings for other purposes. Hospitality facilities in which hospitality services are provided can be separated by a public or shared area. Hospitality facilities can be entered directly from the outdoor area.*

Diffuse and integral hotel in the function of strengthening the competitiveness of tourism in the Republic of Croatia

The association of vacation rentals through a model such as diffuse and integral hotel, with the aim of strengthening the competitiveness of tourism of the Republic of Croatia is one of the key activities of the “National Program for improvement of vacation rentals” which should result in:

- the creation of new and innovative tourist products in the destination,
- the development and improvement of the quality of the accommodation offer,
- the realization of common interests and joint appearance on the market,
- market recognition of accommodation facilities,
- professionalization of family accommodation,
- increasing occupancy in the pre- and post- season, and
- stimulating micro economy [25; pp.30-34].

According to the data of the Ministry of Tourism of the Republic of Croatia 2 diffuse hotels with a total capacity of 62 beds and 22 integral hotels with a total capacity of 905 beds were registered [30]. Diffuse hotels are located in Istria and Zadar County, while integral hotels are the most numerous in Split-Dalmatia County, 10, three in Zagreb and Dubrovnik-Neretva County, two in Karlovac and Primorje-Gorski Kotar County and one in Istria and Zadar County. Existing diffuse and integral hotels and their quality will not be described and analyzed here, because this is a separate topic that requires a different approach and separate scientific work.

Diffuse and integral hotel in the Republic of Croatia according to the “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels”: types of facilities and minimum standards

According to research carried out for the purposes of this scientific paper, although there is a significant increase in integral hospitality in the Republic of Croatia, there has not been a collective association (business association) of vacation rentals, i.e. private renters. All registered and categorized integral hotels are not organized by uniting of existing registered service vacation rentals but by re-categorizing vacation rentals into an integral hotel with several accommodation units, primarily apartments, the same owner. Due to the prescribed business operating conditions of diffuse and integral hotels, there is no strong motivation of family accommodation owners to professionalize their business through the model of diffuse and integral hospitality.

The **diffuse hotel** can be organized exclusively in historical and traditional buildings in small settlements (villages) and towns that are decorated and equipped in a traditional way. The hotel can consist of at least three traditional buildings scattered throughout the resort. The basic services of the hotel are accommodation and breakfast. Accommodation is not pre-categorized, it is categorized when registering a hotel. This means that the entire hotel (both accommodation and other services) is categorized according to the prescribed minimum conditions. Breakfast and other hospitality services can be provided in their own space (own restaurant) or connected to existing restaurants in the village. The hotel must have a central reception with all the prescribed elements specified in the Minimum Standards of the “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels” [17]. The hotel must operate as a craft, cooperative or company. The owner of the hotel can be one person if he owns at least three buildings (which are not previously categorized for the provision of accommodation services) and which are placed in the function of the hotel, or several owners of buildings that join or organize through the hotel. The aim of the diffuse hotel is to arrange and put into operation traditional buildings in rural and urban settlements and joint (multiple owners of buildings) business organization through the hotel.

An **integral hotel** can be organized in any settlement/resort and is not conditioned by traditional buildings as a diffuse hotel, i.e. any functional building comes into account. The hotel can consist of at least three buildings scattered around the settlement/resort. The basic services of the hotel are accommodation and breakfast. Hotel accommodation consists exclusively of pre-categorized accommodation, i.e. accommodation of registered vacation rental owners in the settlement/resort. This means that when registering a hotel, accommodation is not categorized, because the existing quality star rating is recognized, and the quality star rating of hotel is done according to the prescribed Minimum Standards of the “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels” (reception, etc.) [17]. Breakfast and other hospitality services can be provided either in their own space (own restaurant) or connected to existing restaurants in the settlement/resort. The hotel must have a central reception with all the prescribed elements specified in the Minimum Standards of the “Ordinance on the classification, quality star rating and special standards of hospitality facilities from the group Hotels” [17]. The hotel must operate as a craft, cooperative or company. According to the current legislation in Croatia, vacation rental owners make their entire accommodation capacity available to the hotel, which means that they lose their autonomy and can operate on the market exclusively through the hotel, not independently, or can fill capacity through travel agencies or directly on the market (their own booking). In this case, vacation rental owners lose the status of a lump sum taxpayer and pay all tax liabilities (income or profit tax, any value added tax) through the hotel. They also pay tourist tax and tourist membership fees through the hotel. This means that vacation rental owners become one business unit and operate exclusively through the form of a hotel, and only the existing quality star rating of accommodation is recognized. The aim of the organization of an integral hotel is to consolidate the offer of vacation rentals and their business through the model of small hotel business.

Difficulties in organizing a diffuse and integral hotel in the Republic of Croatia would be:

- Vacation rental owners lose their autonomy and can no longer directly operate through travel agencies and tour operators or charge their facilities independently. Most vacation rental owners operate through travel agencies or OTA (online tourist agency such as, for example, Booking.com [31]), and for the executed and charged reservation they approve the agreed commission to the agency, i.e. they know in advance what their income and cost (commission) is per reservation for bringing guests.

- Vacation rental owners already have a well-established network of business with travel agencies and independent appearance on the market, which through the association of diffuse and integral hotels should be waived. A diffuse and integral hotel can take over business with agencies with which private renters operate, but this makes business more expensive for renters. Specifically, this means that now the commission to the vacation rental owner is the cost approved by the agencies of, for example, 15 % for the reservation/booking of accommodation. Operating through a hotel increases the cost to the renter because the hotel pays a 15 % commission to the agency, and the vacation rental owner must give the hotel a portion of the earnings of at least 10 % in order for the hotel to finance its current operations: employee salaries, overhead costs and more. The possibility of the hotel entering the value added tax system very quickly should also be taken into account, which means that the price of accommodation for vacation rental owners will increase by 13 %, which calls into question further competitiveness.
- It should also be taken into account the fact that vacation rental owners with travel agencies have contracts mainly concluded for a year, which cannot be terminated during the season without penalties, which means that even if they wish to do business exclusively through an integral hotel, terminating contracts with agencies before the contract expires will not be “painless”.
- The 16-hour reception hours require at least three full-time employees and raises the issue of financing employees’ salaries and other expenses. Vacation rental owners are not motivated to pay employees and other hotel expenses when they do not know in advance whether they will fill their capacities through the hotel.

PROPOSALS FOR IMPROVING THE ORGANIZATION AND OPERATION OF DIFFUSE AND INTEGRAL HOTEL IN THE REPUBLIC OF CROATIA

In order to improve the organization and operations of diffuse and integral hotels in the Republic of Croatia, the implementation of the following proposals should be considered:

- Allow diffuse and integral hotels to operate with vacation rental owners on the principle of “on behalf and for account” of hotel stakeholders or vacation rental owners. Vacation rental owners in this case retain their autonomy. The establishment of a hotel, the expansion of business and the provision of services to renters (in addition to filling the capacity and cleaning system of the facility, the organization of guests’ free time, etc.) will motivate renters to leave their business to the hotel.
- Vacation rental owners should remain in the lump sum taxation because if they operate through the hotel on a principle of “on behalf and for account”, when the hotel enters the value-added tax system, they remain competitive with prices, do not enter the value-added tax system individually and are not in the obligation to keep bookkeeping individually.
- Allow autonomous determination of the opening hours of the reception of the hotel according to the possibilities, and at a time when the reception is not open allow the receptionist to be contacted by phone.
- Enable the introduction of capital grants by the ministry of tourism exclusively for diffuse and integral hotels with the possibility of financing the salaries of hotel employees for at least one year from the registration of the hotel.
- Diffuse and integral hotel should be a model of business organization and additional offers for vacation rental owners, which can be interesting to guests and target groups for arrival to the destination and outside the main tourist season which lasts from June to September.

Diffuse and integral hotel is a receptive structure composed of several connected accommodation providers and several providers of other tourist and hospitality services with a

unique management (administration). The management structure manages the business of the integral hotel based on the annual business plan and defined tasks. It is of great importance to establish a model of management structure that will be functional and efficient. Diffuse and integral hotel, as a structure that is oriented towards the entire destination, manages accommodation capacities and through networking creates, implements and manages additional innovative facilities and services with the aim of creating experiential experiences of hotel guests in the historic center.

Business connection of stakeholders of diffuse and integral hotels (vacation rental owners and other service providers) is done by contracts (contracting rights and obligations related to business). The contract can be signed in two ways in accordance with the provisions of the Croatian “Act on Mandatory Relations” [32]:

- *A contract “on behalf and for account” of a stakeholder (vacation rental owners and other service providers) when only agency commission approved by the stakeholder is considered revenue. If the integral hotel would exceed the threshold of HRK 300,000.00 of revenue per year and enter the value added tax system, then that tax is paid only on the amount of the commission. In this case, it is a commercial representation when the shareholders have authorized the diffuse and integral hotel as an agent to perform certain tasks in its name and on its behalf. For these transactions, the shareholders of the hotel (agent) approve the agreed commission. Here the business operator/holder of activity is a vacation rental owner and other service providers and all legal responsibility for the service provided is theirs. The diffuse and integral hotel has the function of an agent and may not offer accommodation at a price other than that determined by the shareholders (vacation rental owners and other providers of tourist and other services).*
- *Contract in “own behalf and on the own account” of shareholders (vacation rental owners and other service providers) when the income is considered to be the total amount charged for the service and in the case of entry into the value added tax system, that tax shall be paid on the entire amount of the invoice collected. When working according to the contract in its own behalf and for its own account, then the diffuse and integral hotel as an agent becomes the bearer of activities and responsibilities, forms the price as it wants, makes a difference in price and fully disposes of accommodation and other services for which such a contract has been concluded.*

Business connection in a diffuse and integral hotel will enable:

- active participation of all interested stakeholders in further conceptions of the hotel’s business policy,
- joint planning, implementation of activities and sales of services with the aim of better selling capacity, increased competitiveness and quality of products and services,
- organizational and technical assistance to vacation rental owners in all business segments (consulting) and solving common needs such as parking for hotel guests, card business and others,
- stronger marketing and promotional connections with tourism markets,
- protection of interests and improvement of the negotiating position towards public institutions, local, regional and national state administration, agencies and tour operators,
- informing about all changes, modifications and new legal regulations of importance for diffuse and integral hotel activities, private renting and tourism in general, and
- through the development of packages of services, products and special activities, activation of business resources but also destination attractions, which will allow occupancy capacities outside the tourist season (October-April) and improve occupancy in the main season (May-September).

CONCLUSION

The results of this research showed the organizational and legislative framework for the development of diffuse and integral hotels in the Republic of Croatia. The diffuse and integral hotel has the strategic goal of networking the existing stakeholders of tourism service providers into a unique, competitive, innovative and complex tourism product. It also plays an important role in fostering mutual trust and concrete cooperation between vacation rental owners, caterers and other service providers through hotel entrepreneurship. Furthermore, the diffuse and integral hotel offers the tourist market an integral tourist product based on experiential experiences for the guest, strengthens the visibility of destinations in tourist markets and achieves a better market share. The diffuse and integral hotel is focused on year-round operations instead of seasonal ones, with the intention of raising the occupancy of accommodation capacities of private renters during the year, and thus encourages raising the quality of accommodation capacities, creating new tourist services and facilities, for example, congress tourism, wedding tourism, pet friendly tourism, tourism of special interests based on cultural specifics and others. The model of diffuse and integral hotels encourages the revitalization of abandoned and demolished historic buildings by connecting them and putting them into tourist function, and this allows solving specific difficulties in tourist infrastructure such as, for example, organized parking, luggage transport and more. Finally, the establishment of a diffuse and integral hotel indirectly encourages the inclusion of residents in tourism processes through, for example, arranging and decorating their own place of residence in order to increase the visual identity of the place, and also encourages new employment of highly educated and skilled employees trained to serve modern tourism services.

Diffuse and integral hotel is organized with the aim to professionally connect vacation rental owners and other providers of tourist services with the main purpose of stronger and more purposeful business, in order to create a new tourist product, but also to further improve the functioning and articulation of the tourist offer of the place. A diffuse and integral hotel is not a tour operator or travel agency that deals exclusively with contracting the sale of accommodation facilities and other tourist services. Diffuse and integral hotel is a business connection and networking in order to achieve better market share, but also to create a new innovative tourism product and does not exclude the connection of vacation rental owners with specialized agencies and tour operators or autonomous filling/charging of accommodation facilities/capacities.

Diffuse and integral hotel represents a great opportunity to achieve greater competitiveness of Croatian tourism by increasing the quality of vacation rental products and services and through business associations to use all resources that can contribute to the diversification of services. In this regard, it will be necessary to improve Croatian legislation in order to maximize the effects and benefits of diffuse and integral hospitality.

The implications of this article on science can be seen through research and study of sustainable tourism business models at the destination level, their impact on the economy of the local community, social inclusion and, in particular, valorization and revitalization of cultural heritage in the function of tourism offer. Modern tourism development policy is based on a responsible approach and in this sense this article contributes to the theory of science by analyzing the business models of diffuse association, their impact on destination development and, in particular, their importance to raise the competitiveness of the destination. In practical terms, the contribution of this article is reflected in clearly defined guidelines for the improvement of legislation, i.e. the minimum technical conditions that would contribute to greater acceptability of this business model in the private sector in tourism (renters) in order to improve market share and market visibility.

The aim of this article was to describe and interpret the most important structural characteristics of a diffuse and integral hotel and to analyze the legislative framework. The contribution is a concrete proposal to improve the business conditions of diffuse and integral hotels in the Republic of Croatia, detection of restrictive conditions for the organization and operation of diffuse and integral hotels in the existing legislative framework and, at the same time, elaboration and analysis of proposals for their improvement.

The originality of this article can be seen through the fact that for the first time made an integral analysis of existing legal business models of diffuse hotel industry in the Republic of Croatia, analyzes the legislative framework and give critical review of the restrictive minimum technical conditions governing diffuse hospitality. Also, the originality of this article is that it is the first time worked out a proposal to improve the legal requirements that would contribute to the greater prevalence of this business model as an acceptable tourist product in the Croatian tourist destinations.

This article, undoubtedly, represents a contribution to further scientific and professional research of diffuse and integral hotel as business models of association in tourism industry and models of sustainable and responsible resource management in a tourist destination. It provides an analysis and presentation of current business conditions, which may encourage future researchers of this topic to further research comparative analysis of Croatian and European diffuse hotels, quality standards in diffuse hotel industry, the acceptability of this model among private renters in terms of common market approach, models of urban and rural diffuse hotels, marketing and promotional activities of diffuse hotels, etc.

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THE EFFECT OF CUSTOMERS' ATTITUDES TOWARDS CHATBOTS ON THEIR EXPERIENCE AND BEHAVIORAL INTENTION IN TURKEY

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ABSTRACT

Chatbots are a recent technology that brands and companies adopt to provide 24/7 customer service. However, some customers have several concerns regarding technology, and therefore, prefer talking to humans rather than chatbots. Brands must improve their chatbots based on customer experience because customers satisfied with chatbots are more likely to use them to contact brands/companies. Therefore, this article investigated the effect of perceived ease of use, usefulness, enjoyment, and risk factors on customer experience and behavioral intention regarding chatbots. The study also looked into the impact of customer experience on behavioral intention. The sample consisted of 211 chatbot users of Turkish recruited using non-probability convenience sampling. Data were analyzed using the Statistical Package for Social Sciences (SPSS) and SmartPLS3. The results showed that perceived ease of use and usefulness affected behavioral intention, but perceived risk had no impact on customer experience and behavioral intention regarding chatbots. Perceived enjoyment affected only customer experience. Lastly, customer experience affected behavioral intention.

KEYWORDS

customer service, chatbot, customer experience, behavioral intention

CLASSIFICATION

JEL: C88, M31, Q55

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INTRODUCTION

Advances in technology have resulted in revolutionary applications (apps) that change the way business is conducted. For example, Artificial Intelligence (AI), as it is today and will be in the future, has become a critical component of digital transformation for businesses. Today, customers spend more time on digital platforms, pushing brands/companies towards incorporating digital services into their operations.

Marketing is one of the areas most affected by advances in technology. We can see the repercussions of technological developments in customer behavior, brand management, and customer service. For example, brands/companies, especially in developed countries, widely use chatbots for 24/7 customer service in online shopping, finance, banking, health services, gaming, and catering. Chatbots are AI digital assistants that mimic human speech [1]. Most customers are accustomed to using chatbots due to their advantages. Chatbot technology can be traced back to the question "Can machines think?" first posed by Turing in 1950 [2]. Chatbots have made significant progress in the following decades and turned into a popular technology as we know it today. Customers can use them to check their bank accounts, make online transactions, report power shortages, describe locations, find information about touristic destinations and fares and public transport timetables, buy tickets and book hotels, communicate with smart home devices, and order out [3]. It may seem complicated or futuristic to brands/companies to use chatbots to sell products/services or provide customer service. Still, it should be kept in mind that chatbots are a promising technology for improving sales, marketing, customer service, and customer experience.

It is thought that this research, which was conducted to determine the effect of chatbots usage levels by consumers and their attitudes towards chatbots on customer experience and behavioral intention, will contribute to the literature as well as brands and companies that want to use or develop chatbots.

THE CONCEPT OF CHATBOT AND ITS TRANSFORMATION

Chatbots, or chatterbots, are software programs designed to simulate a smart conversation with one or more users through text chats and voice commands. Chatbots can make short conversations and answer users' questions according to the context and the incoming message. Chatbots are one of many examples of AI [4]. They are defined as computer programs that simulate human speech through text-based dialogue systems [5]. In other words, they are virtual speech service robots that facilitate human-computer interaction [6]. Chatbots, also known as conversational bots or artificial conversational entities (ACE), are AI software apps that speak in natural languages through voices or texts. Brands/companies prefer to use chatbot technology more and more because it helps them provide 7/24 customer service as a labor-cost, and time-effective alternative to the conventional way of doing business [7].

Digitalization and the rising popularity of the Internet and mobile technology have drastically changed the way people interact with each other and with companies. With the Internet, digital platforms and mobile devices have become technologically intertwined, sparking a boom in the e-commerce market [8]. Brands/companies use chatbots because they provide 24/7 service to customers by answering their questions, informing them about products/services, and helping them make purchases. It would not be wrong to think of this guide robot software apps as "artificial assistants." Chatbots have a wide range of uses; they can provide users with detailed information about products/services, manage their schedule, advise on the best route and purchase tickets, book hotels, order groceries, and help them save time and money when shopping online [9, 10]. Since Turing [2], there has been a growing body of research on human-

computer interaction. Siri, Eliza, Alice, Ella, Evi, S-Voice, Jeannie, and CallMom are the first virtual assistants that come to mind. Eliza is the earliest chatbot, which was developed by Joseph Weizenbaum in 1966. Weizenbaum was a therapist interested in inventing a therapist robot that could answer questions [11].

Chatbots are useful programs that help people with daily tasks, such as sending automatic reminders and notifying them about tasks in progress, drawing up texts or emails, answering simple financial questions, and booking everything from flight tickets to hotel rooms [12]. Chatbots mimic written or spoken speech to simulate a conversation with customers. They are promising digital solutions designed to enhance the e-commerce industry. There are various types of chatbots according to different authors. For example, according to Araujo and Casais there are two types of chatbots: keyword-based and machine learning-based. Keyword-based chatbots are somewhat limited as they only respond to predetermined commands. Machine learning-based chatbots, despite errors, can detect the user's language. Purchasing assistants play an essential role in conventional business life because they offer store support, provide information about products/services, and simplify decision-making processes. Chatbots play the same role in the digital world. They serve as shopping assistants in physical and online stores [13].

As stated earlier, chatbots are just one type of speech agent. However, there are different types of chatbots, which react differently to users. In addition, different classifications are made according to different authors. There are four types of chatbots [14].

Flow-based chatbots use conversational flows defined by developers. The user goes through a certain number of questions and options and chooses one of the options offered by the developer. They contain many buttons and keywords, out of which the user can select to take action. They are also called “rule-based chatbots” because they are designed to perform several tasks based on rules laid down by their developers.

Artificial intelligence chatbots: AI efforts to modeling human language have been futile in the last half-century. Scientists have had to tackle the complexity of human language in terms of comprehension and generation. The true challenge for computers is not understanding words but understanding the contexts in which those words are used. However, decades later, the situation has changed with different natural language interactions through speech agents. Today, Instant messaging (IM) is one of the most popular forms of the content management system (CMS). Therefore, chatbots are an essential part of the CMS. AI chatbots mimic human personality, behavior, and dialogue to deliver a unique user experience. In other words, they respond to users within the context of the conversation. AI chatbots allow the user to interact freely and have a real discussion. The user can enter a sentence, and the bot can analyze a number of parameters to understand his/her intention and reaction.

Hybrid chatbots combine the best features of earlier bots (flow-based and AI bots) for a better user experience. Most chatbots are hybrids because Natural Language Processing (NLP) technology is still not advanced enough to understand every sentence. This means that the user cannot always get the answer he/she seeks. Hybrid chatbot users go through a series of questions as in flow-based bots, but they can also ask questions through texting.

As the name implies, **human-powered chatbots** are chatbots backed by a team of humans to allow users to interact using free texting. In other words, human-powered chatbots are monitored by human operators who take over the conversation when the bot fails to meet customer demands. The advantage of these chatbots is that operators can manage them. Therefore, trained and guided bots are likely to interact better and give better responses in the future.

Companies make use of AI apps, such as chatbots, in many areas, especially in sales. According to an article published by the Harvard Business Review, AI technology increases possible

sales figures by 50 % and reduces customer service costs by 40 % to 60 % and customer call time by 60 % to 70 %. Chatbots are also experts in automating customer service. It is estimated that 35 % of chatbot usage will be reserved for customer service by 2024. Research also shows that chatbots with “personality” and “humanity” will be more popular [15].

CHATBOTS AND CUSTOMER SERVICE

Online customer service is defined as any service to meet customer needs and demands, provide goods/services that appeal to them and track them online. Conventional customer service employees interact face to face with customers. On the other hand, online customer service employees respond to emergencies outside the facility. Customers using both online and offline services have recognized that the former is more efficient, accessible, and time and cost-effective than the latter. Therefore, widespread digital service and marketing offer a world of possibilities to brands/companies to meet customer needs and demands [16]. Chatbots are new interfaces that transform the way brands/companies interact with customers [3]. They are the latest AI technological innovation for customer interaction and commercial success [17].

Chatbots are useful for both brands/companies and customers because customers interested in products/services can easily communicate with chatbots to learn more about them [9]. Customers appreciate chatbots that inform them about products/services and offer them a unique shopping experience [18, 19].

One of the advantages of chatbots is that brands/companies can use them 24/7 [20]. Using chatbots as customer service in apps like Facebook is quite profitable [7] because it helps the company save costs and provide high-quality offline customer service. Chatbots allow customers to click to contact customer service, receive personalized recommendations, and purchase on messaging apps [7]. Most companies interact one-on-one with their customers on smart devices via chatbots, reducing costs and increasing customer satisfaction [21]. Chatbots improve online customer experience by creating a sense of real human being speaking and serving at the right time [22]. Messenger apps and chatbots are digital services that allow customers to access products/services online anywhere and anytime and help them find what they are looking for and make informed purchase decisions [8]. The other advantages of chatbots for brands/companies are as follows [15]:

- AI systems are more accurate in every sense. They provide more objective information and have more control over customer interactions,
- chatbots promote brand image because they offer 24/7 customer support, giving customers the feeling that they are always being listened to and cared for. Unlike real customer representatives, chatbots can assist a large number of customers and answer multiple questions at the same time. In this way, customers are never put on hold and can get an immediate and accurate response,
- in every chatbot-customer interaction, the user provides information about their preferences, interests, and communication channels. Brands/companies use that information to learn more about new markets and opportunities and increase their sales,
- chatbots are a straightforward way of communication, allowing customers to get answers to their questions or find solutions to their problems quickly and easily. Chatbots also store previous records and requests, which facilitates subsequent interaction,
- customers interacting with chatbots are likely to trust brands/companies using that technology more because they take less risk of errors when seeking solutions to their problems,
- customers using AI-powered apps are less concerned about giving away personal information because they know that such apps are designed to protect their privacy,

- chatbots learn from every interaction with customers and combine new information with prior knowledge to make the interactions more personalized, forging the bond between customers and companies/brands,
- customer service chatbots allow customers to have a more transparent, integrated, and personalized experience, which is critical for brand/company-customer interaction.

Many companies have recognized the advantages of chatbots and started to use them for customer service. For example, the Facebook Messenger app had more than 34 000 chatbots in 2017 [23]. At this rate, the chatbot market size is estimated to reach \$ 1,25 billion in 2025 [24].

Chatbots are widely used by brands/companies operating in numerous sectors (online shopping, finance, banking, healthcare, tourism, catering, etc.). Those brands/companies offer high-quality service because chatbots can answer customers' questions and solve their problems quickly, leaving them satisfied [9]. Such brands/companies see chatbots as a great opportunity to take advantage of social networks and stand out among rivals through relational marketing in the digital environment [13]. Many brands/companies use chatbots. For example, IKEA, Lloyds Banking Group, and Royal Bank of Scotland use chatbot assistants as their first point of contact with customers [4]. DBS Bank, based in Singapore, has its own chatbot called DigiBank, a text and voice-based virtual assistant. Customers can manage their currencies, check their transaction history and interest rates, and make payments. The Bank of America, Ally Bank, Capital One, and Barclays Africa also have their own chatbots [25]. Fashion brands/companies (Prada, Burberry, Lois Vuitton, Gucci, Tommy Hilfiger, etc.) also use customer service chatbots [26]. Burger King allows its customers to place orders on the Facebook Messenger chatbot. Expedia has a chatbot that enables customers to choose hotels and book resort rooms quickly. WeChat uses its chatbots to allow subscribers. Alibaba's AliMe customer service chatbot helps customers place orders and automatically provides them with information on products/services on e-commerce platforms [9]. Prominent German brands/companies, such as Lufthansa and Klarmobil, also use customer service chatbots [7].

Most online shopping sites (e-commerce websites) have chatbots because they have a wide range of products with a large and complex database in each of their categories. Those products are spread over many websites and categorized according to their types. Navigating those websites to find relevant and personalized results can be unintuitive, time-consuming, and exhausting. Users visit e-commerce websites to search for specific products or just to do window shopping. Search tools use keyword matching to display multiple results, some of which may be relevant, while others may not. Irrelevant results lead to unpleasant user experiences. A customer who uses vague keywords to describe a product/service is likely to get irrelevant results. Moreover, conventional systems cannot help a user who knows little about the product he/she is looking for. Chatbots try to overcome these problems by offering a more intuitive interaction between e-commerce sites and users. They interact with customers and suggest the right products. The customer enters keywords directly in the message window. The chatbot matches that input with programmed responses and finds the right or relevant products for the customer [4]. All brands/companies should benefit from chatbots because they are user-friendly and convenient.

Customers are pleased to talk to chatbots with human photos and speech. Organizations and designers are recommended to design anthropomorphic chatbots for customers to have better user experiences [7]. Perceived helpfulness and usefulness play a key role in shaping customers' attitudes towards chatbots [27]. Apart from online privacy concerns, perceived usefulness, ease of use, and compatibility positively affect users' attitudes towards chatbots [13].

Bold360 [28] conducted extensive research, including eight countries, 850 companies, and 4 500 participants. According to its results, customers rely primarily on phones (46 %) and email (40 %)

to interact with brands/companies because they are more familiar with that technology and more comfortable using them. Another reason is that most brands/companies still use smartphone and email technology to communicate with their customers. However, chatbots are becoming increasingly popular. The results also show that two out of ten (20 %) customers have used phone and email technology the last time they interacted with brands/companies. More than seven out of ten customers think that brands/companies should adopt the latest technologies to answer their questions or solve their problems quickly. More than five out of ten customers (54 %) and more than seven out of ten company representatives (76 %) believe that AI technology has changed the customer experience for the better [28].

Chatbots help brands/companies keep in touch with their customers and improve user experience and brand trust. The advantages of chatbots and the recent advances in AI and machine learning have made chatbots a viable option for customer services. Brands/companies pay much more attention to chatbot technology, mainly due to the drastic increase in the number of people using the Internet and other online platforms [9]. For example, Gartner [29] estimated that unattended virtual assistants or chatbots would manage 25 % of customer interaction by 2020 and by 2022, two-thirds of all customer experience projects will make use of IT.

Telegram, WhatsApp, and Facebook Messenger are some of the messaging apps that people use, among other things, to talk to friends, interact with brands/companies, make calls, consume content, purchase products/services, and even book restaurants. Marketers use chatbots in those apps to provide customer service and content, place advertisements, and sell products/services [30]. Watson Assistant, Bold360, Rulai, LivePerson, Inbenta, and Ada are considered the best chatbots. Watson Assistant was developed by IBM, one of the leaders in AI technology. It is one of the most advanced chatbots on the market. Having been trained with sectoral content, Watson Assistant can understand the chat or call logs, look for an answer in the database, ask customers to be more specific, direct them to human representatives, and even make training suggestions for more information. Watson Assistant is compatible with websites, messaging channels, customer service tools, and mobile apps [31].

CONCERNS ABOUT CHATBOTS

Despite a number of advantages, chatbots cause some concerns. First, they may deviate from the pre-programmed script and misinterpret customers' questions and give wrong answers. This can cause frustration on the part of customers. Second, security, privacy, and spam management may be an issue for companies participating in mobile marketing via chatbots [8]. Usefulness, ease of use, and risks play an active role in how customers perceive chatbots. Productivity is the primary reason why customers use chatbots [14]. Therefore, users who think it is wiser to use chatbots despite possible risks are likely to continue to use them.

Another concern about chatbots is that customers expect more from assistants who introduce themselves as human beings. Moreover, a customer feels distrust if a chatbot acts like a human but falls short of meeting his/her expectations, which a human would otherwise meet. Therefore, brands/companies should let customers know that they are really talking to a chatbot, not a human being. If a chatbot creates automatically a shopping list based on previous users orders and preferences, does that list belong to the chatbot or the user? Do brands/companies have the right to sell the user information they collect through chatbots to third parties? If so, do customers have the right to know about it [32]?

In other words, chatbots are still in their infancy, and therefore, are not expected to take over jobs in the foreseeable future. Instead, hybrid human-machine chatbot technology is key to customer experience and satisfaction. However, we should be aware and prepared for the fact that chatbots will become an even more integral part of our lives with the advances in AI technology in the coming years.

CUSTOMER EXPERIENCE

Customer experience is defined as the “aggregate and cumulative customer perception created during learning about, acquiring, using, maintaining and disposing of a product or service” [33]. It is also defined as “the aggregate of feelings, perceptions, and attitudes formed during the entire process of decision making and consumption chain involving an integrated series of interaction with people, objects, processes, and environment, leading to cognitive, emotional, sensorial, and behavioral responses” [34]. In light of these definitions, it would not be wrong to define customer experience as (a) a new way of looking at customer-brand relationships, (b) the cumulative interaction of customers with all value chain members and objects provided by an organization, and (c) a means of making a long-lasting impression on customers [35]. Today, the market is very integrated, and therefore, brands/companies should redefine customer experience, loyalty, and relationship that are more complex than ever. A company interested in turning into a brand of choice should go beyond simply selling products and place itself in its customers’ everyday lives and offer them an adaptable and useful experience. Advances in technology allow virtual service representatives – or e-service representatives – to improve customers’ experiences and meet their expectations through real-time interaction. Chatbots are one of those technological developments. They play a crucial role in customer-brand/company relationships and enhanced customer experience [9]. We need to determine how customers perceive chatbots’ ease of use, usefulness, entertainment, and risks in order to maximize their benefits. The central assumption of this study was that “perceived ease of use, usefulness, entertainment, and risks regarding chatbots affect customers’ experiences and their intention to use chatbots again.”

PERCEIVED USEFULNESS

It would not be wrong to define the concept of “perceived usefulness” as the benefit derived from the use of chatbots. Herrero and Martín [36] define it as “the degree to which an individual considers that using a particular system will improve the performance in a task.” An individual who thinks that a system, a device, or an app can help him/her complete a task is more likely to use it again [37]. Perceived usefulness has the most significant impact on customers’ attitudes towards chatbots. Therefore, a customer’s attitudes towards a chatbot depend on its usefulness perceived by that customer. This shows that the more useful a person perceives a technology, the more likely it is that he/she will accept it [38]. The attitude born out of perceived usefulness also affects the intention to use [39]. Zamri and Idris [40] also state that perceived usefulness is a critical factor that positively affects purchase intention. Therefore, brands/companies that would like their customers to use chatbots should use a convincing tone to win their trust by informing them of the benefits of using chatbots, such as easier and faster processes, service priority, etc. In this context, the following are hypotheses concerning the effect of perceived usefulness on customer experience and behavioral intention:

H_{1a}: Perceived usefulness of chatbots positively affects customer experience.

H_{1b}: Perceived usefulness of chatbots positively affects behavioral intention.

PERCEIVED EASE OF USE

Perceived ease of use refers to the degree to which a person believes that using a particular system would be free from effort [41]. The more effortless using a system is, the more it can improve work performance. Research shows that perceived ease of use affects perceived usefulness and is therefore related to intention directly and indirectly [42]. Perceived ease of use gives rise to users’ attitudes towards technological devices, which affect their intention to use those devices [39]. Chatbot developers interested in reaching a large number of customers should find ways to make sure that users consider chatbots easy to use. On the contrary,

perceiving chatbots as hard-to-use may negatively affect customers' experience of using them [35]. Developers should overcome the challenges of low education level and advanced age, which prevent some customers from using chatbots. Those who find chatbots hard to use are likely to share their experience with people they know, which will deprive brands/companies of new customers. Conveying the message that customers of all ages and education levels can easily use chatbots can significantly increase the number of users. Perceived ease of use affects both customer experience and intention to reuse. In this context, the following are hypotheses concerning the effect of perceived ease of use on customer experience and behavioral intention:

H_{2a}: Perceived ease of use of chatbots positively affects customer experience.

H_{2b}: Perceived ease of use of chatbots positively affects behavioral intention.

PERCEIVED ENJOYMENT

Customers may enjoy using a particular system and think that using new technology is fun. Of course, the opposite is also possible. Perceived enjoyment is defined as the extent to which using a system or device is perceived as enjoyable in its own right, apart from any performance consequences [43]. High perceived enjoyment positively affects behavioral intention. In other words, customers who enjoy using a system are more likely to use it again [44]. Therefore, brands/companies should definitely take the factor of "enjoyment" into account when designing chatbots. A person who finds a system unpleasant, cold, and boring is likely to have negative customer experiences and low reuse intention. In this context, the following are hypotheses concerning the effect of enjoyment on customer experience and behavioral intention

H_{3a}: Perceived enjoyment of chatbots positively affects customer experience.

H_{3b}: Perceived enjoyment of chatbots positively affects behavioral intention.

PERCEIVED RISK

The concept of perceived risk is defined as "consumers' perceptions of the uncertainty and adverse consequences of buying a product or service" [45]. Customers face five types of risks: financial, time, psychological, social, and performance [46]. Every purchase involves one or more of those risks. Customers should be aware of those risks and draw up plans and strategies accordingly [47]. Customers may encounter privacy violations when purchasing products or services on chatbots. For example, their personal information (such as phone number, name, or address) may be misused or shared with unauthorized third parties [8]. There is always an inconsistency between users' judgments and the actual performance of technology. Users are often unaware of the consequences of that inconsistency, which can pose various risks. If the chatbot causes unexpected problems, the customer will perceive high risk and stop using the chatbot and instead will prefer to wait for a long time to just talk to a human being. What is more, he/she is less likely to use the chatbot again. The higher the risk a customer perceives for a good or service he/she has purchased, the more negative experience he/she is likely to have. Therefore, studies on technology should examine the role of risk. In this context, the following are hypotheses concerning the effect of perceived risk on customer experience and behavioral intention:

H_{4a}: Perceived risk of chatbots negatively affects customer experience.

H_{4b}: Perceived risk of chatbots negatively affects behavioral intention.

BEHAVIORAL INTENTION

Behavioral intention refers to the likelihood of a person using mobile messaging chatbots. Attitudes towards chatbots and behavioral intention are interrelated. In other words, when we

predict a customer's attitude towards chatbots, we can predict his/her intention to use them [8]. Customers who believe that sufficient resources and infrastructure are available are likely to have a more positive behavioral intention associated with using chatbots. In other words, customers who believe in the effectiveness of technical means (Internet infrastructure and the compatibility between the information, systems, and technology required for online access) are more likely to use chatbots [48]. This study had two assumptions: (1) customers' intention to use customer service chatbots is positively affected by their perceived ease of use, usefulness, and enjoyment of chatbots and is negatively affected by their perceived risk of chatbots and (2) customer experience positively affects their intention to use chatbots again in the future. The following is the related hypothesis:

H₅: There is a positive correlation between customer experience and behavioral intention to use chatbots again in the future.

RESEARCH METHOD

This quantitative study adopted a correlational survey model. Data were collected using the survey method and analyzed using the Statistical Package for Social Sciences (SPSS) and SmartPLS3. SmartPLS is a partial least squares structural equation modeling (PLS-SEM) software package. It is a variance-based structural equation modeling that does not require normal distribution and allows working with a small sample [49, 50].

The study had two main questions: Is there a correlation between customers' perceptions of chatbots and their (1) customer experience and (2) behavioral intention? A research model and hypotheses were developed to answer these questions (Figure 1).

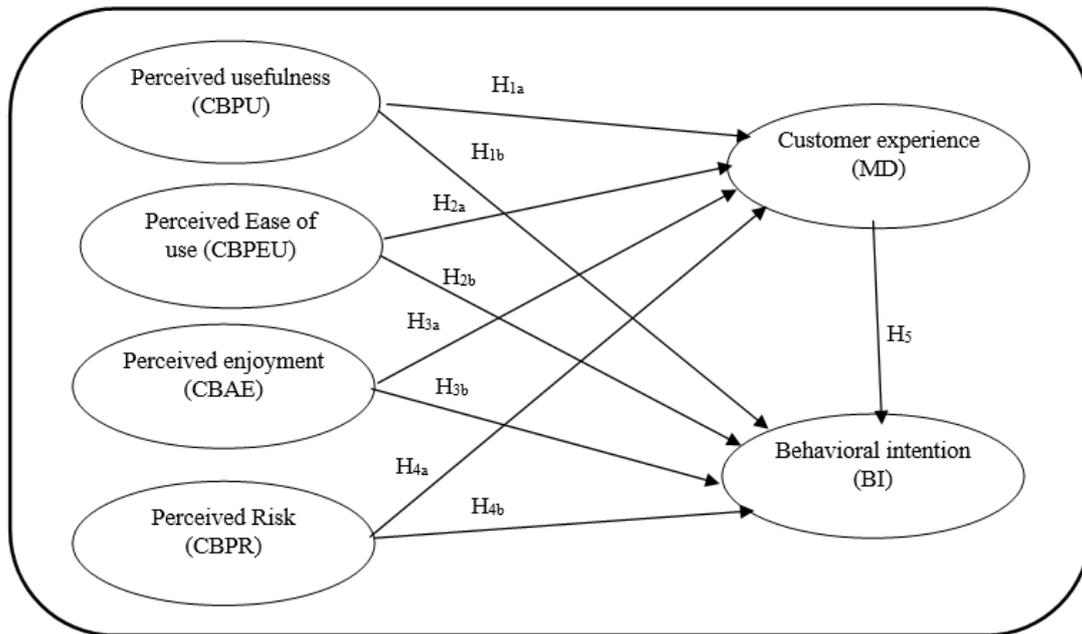


Figure 1. Research Model.

It is seen that there are four exogenous and two endogenous variables in the research model in Figure 1. The exogenous variables are perceived usefulness, perceived ease of use, perceived fun, and perceived risk. The endogenous variables are customer experience and behavioral intention dimensions. Within the scope of the research, it was aimed to learn the effect of exogenous variables on endogenous variables. Accordingly, the research hypotheses in Figure 1 were formed.

POPULATION AND SAMPLE

The study population consisted of all customers with experiences in using chatbots in Turkey. Reaching the entire population is time-consuming and costly. Therefore, the sample consisted of 212 people recruited using nonprobability convenience sampling. One survey was excluded because it was incomplete. Thus, the final sample consisted of 211 participants. Table 1 shows the participants' demographic characteristics.

Table 1. Sample and Demographic Characteristics.

		Frequency	%
1. Gender (Total = 211)	Woman	127	60,2
	Man	84	39,8
2. Age (years) (Total = 211)	17-25	167	79,1
	26-34	29	13,7
	35-43	15	7,1
3. Education (degree) (Total = 211)	Associate's	114	54
	Bachelor's	72	34,1
	Master's	25	11,8
4. Monthly income (TL) (Total = 211)	≤750 TL	122	57,8
	751 L-1000 TL	14	6,6
	1001 TL-1250 TL	9	4,3
	1251 TL-1500 TL	9	4,3
	≥1501 TL	57	27
5. Purpose of chatbot use (Total = 211)	Banking	29	13,7
	Banking, online shopping	11	5,2
	banking, online shopping, ordering out	19	9
	all	14	6,6
	banking, ordering out	2	0,9
	Banking, others	2	0,9
	Online shopping	58	27,5
	Online shopping, ordering out	13	6,2
	Online shopping, ordering out, others	1	0,5
	Online shopping, others	6	2,8
	Ordering out	9	4,3
Others	47	22,3	
6. Customers think that chatbots are ... (Total = 211)	Useful	162	76,8
	Useless	8	3,8
	Neither useful nor useless (undecided)	41	19,4

Of participants, 60 % (127) were women, 80 % (167) were 17-25 years of age, 7,1 % (15) were 35-43 years of age, 90 % (186) had an associate's or bachelor's degree, 11,8 % (25) had a master's degree, 57,8 % (122) had an income of less than 751 TL, and 27 % (57) had an income of more than 1500 TL. Participants can use chatbots for different purposes. In order to reveal these, the answers given to the question asked were examined. Participants used chatbots for banking 63,3 %, online shopping (27,5 %), ordering out (27,5 %), or other reasons (22,3 %). Only eight participants (3,8 %) found chatbots useless, while 41 participants (19,4 %) were undecided about it.

SCALES: RELIABILITY AND VALIDITY

The research model had four exogenous and two endogenous variables. The exogenous variables were "perceived usefulness (four items)," "perceived ease of use (five items)," "perceived

enjoyment (three items),” and perceived risk (three items).” The endogenous variables were “customer experience (three items)” and “behavioral intention (five items).” “Perceived usefulness,” “perceived ease of use,” and “perceived enjoyment” were measured using the valid and reliable scales developed by Davis et al. [42] and Dabholkar and Bagozzi [51]. “Perceived risk” and “customer experience” were measured using the valid and reliable scale developed by Trivedi [35]. “Behavioral intention” was measured using the five-item scale developed by Uğur and Turan [52]. We also established the validity and reliability of the scales. We calculated item-factor loadings, Cronbach’s alpha, and composite reliability (CR) coefficients for reliability and average variance extracted (AVE) coefficients for construct validity. Table 2 shows the reliability and validity results.

Table 2. Item-Factor Loadings and Validity and Reliability Indicators.

Variable	Number of Items	Item loadings	C α	CR	AVE
Chatbot Perceived Usefulness (CBPU)	CBPU1	0,952	0,960	0,971	0,894
	CBPU2	0,929			
	CBPU3	0,946			
	CBPU4	0,955			
Chatbot Perceived Ease of Use (CBPEU)	CBPEU1	0,956	0,977	0,982	0,917
	CBPEU2	0,953			
	CBPEU3	0,958			
	CBPEU4	0,965			
	CBPEU5	0,956			
Chatbot Perceived Enjoyment (CBPE)	CBPE1	0,977	0,979	0,986	0,960
	CBPE2	0,979			
	CBPE3	0,983			
Chatbot Perceived Risk (CBPR)	CBPR1	0,886	0,920	0,949	0,862
	CBPR2	0,948			
	CBPR3	0,949			
Behavioral Intention (BI)	BI1	0,949	0,980	0,984	0,926
	BI2	0,968			
	BI3	0,976			
	BI4	0,971			
	BI5	0,949			
Customer Experience (CE)	CE1	0,974	0,954	0,970	0,916
	CE2	0,931			
	CE3	0,966			

The items had factor loadings greater than the reference value (0,7) and highly represented the variables they purported to represent. The items had Cronbach’s alpha (C α) and composite reliability (CR) coefficients greater than the reference value (0,7), indicating reliability. The items had AVE coefficients greater than the reference value (0,5), indicating construct validity (Table 2).

STRUCTURAL MODEL AND TESTING HYPOTHESES

The SmartPLS 3 software is used first to analyze the measurement theory and then the structural theory in order to determine the relationship between latent variables [53]. Coefficient of determination (R^2), Stone-Geisser’s Q^2 cross-validation, explanatory (predictive) power of endogenous variables, and coefficients of the effect size (f^2) of independent variables on dependent variables are checked to analyze the structural model.

Table 3. Coefficient of Determination (R^2), Stone-Geisser's Q^2 Coefficient.

	R2	Q2
Customer Experience	0,900	0,814
Behavioral Intention	0,925	0,848

Determination (R^2) coefficients analysis is performed to understand the predictive accuracy of a research model and explain the variances of dependent variables. In market surveys, the R^2 values of 0,75, 0,50, and 0,25 are considered substantial, moderate, and weak predictive accuracy, respectively [49]. According to analysis, exogenous variables significantly predict endogenous variables.

SmartPLS involves bootstrapping for testing hypotheses. According to Hair et al. [48, p.145], the two-tailed or two-sided critical t values for 1,65, 1,96, and 2,58 are 10 %, 5 %, and 1 % (significance level), respectively. Bootstrapping is used to calculate mean, standard deviation (STDEV), t, and p values. Table 4 shows the hypothesis test results.

Table 4. Hypothesis Results.

Hypotheses	Mean	Sd.	t (t /STDEV)	P
H _{1a} : Chatbot perceived usefulness → Customer experience	0,203	0,093	2,149	0,032
H _{1b} : Chatbot perceived usefulness → Behavioral intention	0,166	0,083	2,070	0,039
H _{2a} : Chatbot perceived ease of use → Customer experience	0,247	0,084	2,980	0,003
H _{2b} : Chatbot perceived ease of use → Behavioral intention	0,247	0,082	2,948	0,003
H _{3a} : Chatbot perceived enjoyment → Customer experience	0,520	0,075	6,964	0,000
H _{3b} : Chatbot perceived enjoyment → Behavioral intention	0,156	0,081	1,912	0,056
H _{4a} : Chatbot perceived risk → Customer experience	0,014	0,025	0,530	0,596
H _{4b} : Chatbot perceived risk → Behavioral intention	0,002	0,019	0,121	0,904
H ₅ : Customer experience → Behavioral intention	0,420	0,085	4,954	0,000

Of the nine hypotheses, six were confirmed, and three were rejected. H_{3b} was rejected because there was no significant relationship between perceived enjoyment and behavioral intention ($t < 1,96$; $p > 0,05$). H_{4a} ve H_{4b} were rejected because there was no significant relationship between perceived risk and customer experience ($t < 1,96$; $p > 0,05$) and behavioral intention ($t < 1,96$; $p > 0,05$).

There was a positive relationship between perceived usefulness and customer experience ($t > 1,96$; $p < 0,05$) and behavioral intention ($t > 1,96$; $p < 0,05$). There was a positive relationship between perceived ease of use and customer experience ($t > 2,58$; $p < 0,01$). There was a positive relationship between perceived enjoyment and customer experience ($t > 2,58$; $p < 0,01$). There was a positive relationship between customer experience and behavioral intention ($t > 2,58$; $p < 0,01$).

DISCUSSION, CONCLUSION, AND SUGGESTIONS

Brands/companies incorporate technological developments into their customer services. Chatbots are one of those developments that are becoming more and more popular due to

positive customer experience and feedback. Customers can use chatbots to check their bank accounts, make online transactions, report power shortages, describe locations, find information about touristic destinations, fares, and public transport timetables, buy tickets and book hotels, communicate with smart home devices, and order out. We think that brands/companies will use technology (Internet of Things, AI, 3D printers, augmented reality, virtual assistants, chatbots, and robots) more widely to perfect customer experience in the coming years. Therefore, research on chatbots is of paramount importance. This article focused on the 211 chatbot users in Turkey and obtained significant results.

The results showed that perceived ease of use positively affected customer experience and behavioral intention. In other words, participants who considered chatbots easy to use were more likely to have a positive customer experience and use them again. This result is consistent with the literature [8, 13, 14, 54, 55].

The results showed that perceived usefulness positively affected customer experience and behavioral intention. In other words, participants who perceived chatbots as useful tools were more likely to have a positive customer experience and use them again. This result is consistent with the literature [8, 13, 14, 54-58].

The results showed that perceived enjoyment positively affected customer experience but had no effect on behavioral intention. In other words, participants who enjoyed using chatbots were more likely to have a positive customer experience but were not more likely to use them again. Cheng and Jiang [59] reported similar results. However, Uyar [57] found a relationship between perceived enjoyment and behavioral intention.

The results showed no relationship between perceived risk and customer experience and behavioral intention. In other words, participants who considered chatbots potentially risky did not have a negative customer experience and did not intend to avoid using them again in the future. Rashid et al. [56] reported that perceived risk affected behavioral intention. Candela [14] found that users' perceived risk of chatbots negatively affected their intention to use them again. Trivedi [35] also found that perceived risk affected customer experience. Therefore, our results on perceived risk differ from the literature. Based on the results, brands/companies interested in using customer service chatbots should:

- develop communication strategies to learn more about their customers' demographic characteristics,
- place customers at the center of their communication strategies,
- let their target audience know that they are there to provide 7/24 customer service,
- inform customers of chatbot services,
- emphasize how easy and fast it is to use their chatbots,
- let their target audience know that their chatbots have friendly/appealing/neutral, and customizable personas,

LIMITATIONS

The study had three limitations. First, the data were cross-sectional. Longitudinal data can provide more information on customers' experiences with chatbots. Besides, the more popular and advanced chatbots become in Turkey, it is likely that we will get different results. Second, we addressed customers' experiences in using chatbots in various sectors. Therefore, future studies should focus on one sector (banking, e-commerce, etc.) to gain more insight into customers' experiences with chatbots. Third, the sample size was moderate. Future studies should recruit larger samples to better understand the factors affecting customers' experiences of chatbots.

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THE SIGNALING GAME OF A FIRM WITH UNKNOWN PROFITABILITY AND AN INVESTOR

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ABSTRACT

A relationship between a firm and a potential investor, when a firm is in the need of funds to take advantage of a valuable investment opportunity, is modeled as a signaling game. The goal of the article is to revise a game theory model of R. Gibbons, in which an investor does not know whether the profitability of a firm is high or low, in a moment when he needs to accept or reject an equity stake offered in exchange for the funds needed for the project's realization. The signaling game of a firm and an investor is shown graphically along with the description of conditions, under which there is the existence of separating or pooling equilibrium. In an extended model, a function is defined for describing the lowest equity stake in a firm, which a rational investor would accept when there are three types of firms in a market. A wider set of possible equilibriums is analyzed by defining the level lines of the function. Conditions under which there is the existence of a separating, a semi-separating, and a pooling equilibrium, are described analytically and graphically. In this way, a clear insight is gained as to which share of financially attractive projects is not realized due to the problem of incomplete information in the signal game of firms and investors.

KEY WORDS

game theory, signaling game, Bayesian theorem, information asymmetry, investment

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INTRODUCTION

Nowadays, firms with different types of profitability are facing financial problems in the sense that they are missing financial funds for the realization of projects which will increase their value. Therefore, a firm needs to find an investor who will secure needed funds. In the perfect world, investors should invest in all projects whose return is bigger than the return of an alternative investment with an alternative rate of return. The imperfection of a relationship between a firm and an investor is described as information asymmetry, which causes a lot of attractive projects to fail due to the lack of financing. Because of that, this problem has significant economic implications and the question is being raised about a type of contract between a firm and an investor which will ease the consequences of information asymmetry. In designing the contract, it must be considered that an investor is usually not aware of information about the profitability of a firm or the value of the project.

In the literature, this problem was faced in different ways. Leland and Pyle [1] are describing a signaling model in which the information about a project's quality is known only to an entrepreneur, and are showing how the willingness to invest, is a signal about a project's quality. Bhattacharya [2] follows this approach in his analysis of dividends as signals and draws interesting comparatively static results. Myers and Majluf [3] analyze a model in which a manager has information about a value of a firm and a net present value of an investment. The firm can be in two different states and the sum value of the firm is divided into new and old shareholders depending on the market value of the firm, the intrinsic value of the firm, and the investment. Gibbons [4] is assuming that a project value is a common knowledge, but, unlike the analysis of Myers and Majluf, Gibbons analyses the whole specter of equity shares that a firm can offer to an investor. He is describing the concept of perfect Bayesian equilibrium and in a signaling game of a firm and an investor presents conditions under which there is the existence of a pooling or a separating equilibrium in a model with two types of a firm. Forges and Renault [5] are dealing with the concepts of equilibriums, especially the perfect Bayesian equilibrium, which is needed for the analysis of the more complex games. A signaling game is a dynamic game with incomplete information, and for the analysis of that type of game, knowledge about the Bayesian formula and conditional probability [6] is needed. Also, Bergemann and Morris [7] are covering both topics, the concept of equilibriums and the Bayesian formula, in their work about games with incomplete information, while Bergh, Ketchen, and others [8] talk about information asymmetry in the management practice. On the same track is Oskar Colombo [9] with his work about signaling as a way to overcome information asymmetries and reduce the uncertainty while in the search for fresh capital. Chandra [10] is solely focused on investment and management portfolio, and approaches the subject from a finance domain standpoint.

Gibbons [4; p.207] states that a separating equilibrium always exists in the signaling game of a firm and an investor. In this article, it is shown that this result is incorrect. The signaling game in the article is shown graphicly so the clear order of moves and payoffs is visible. In the comprehensive analysis, it is clearly stated for which probabilities of the firm's types exist either the separating or the pooling equilibrium. The results shown in the model with the two types are generalized in the extended model with the three types of firms.

The function that describes the lowest equity stake which a rational investor would accept when he creates a belief about a type of firm is shown both graphicly and analytically, along with her properties. The analysis of level lines of the lowest equity stake function enables to differentiate cases and to describe the equilibrium. The contribution is reflected in a visual

display of conditions under which there is the existence of the pooling, the semi-pooling, and the separating equilibrium in the model with three types of firms.

In practice, especially in capital markets, it is usual that a relationship between a firm and an investor is characterized by information asymmetry. The firm's situation is clear due to superior information and rational strategy is easy to find. However, in a perfect Bayesian equilibrium, the investor's strategy needs to be in accordance with a created belief about which type could have sent the signal. Therefore, practical use of a concept for an investor willing to invest money in a capital market would be to create a belief and make a rational choice based on the frequency of occurrence of each type of firm in a market and his knowledge about a market. It is important to highlight that a firm should anticipate the behavior of an investor in order to be sequentially rational. That being said, the model with three types is more precise than a model with two types because it is more realistic to expect a higher diversity of firms in a market.

After the introduction, the article is revising Gibbon's model with two types of firms and the stated results are being reviewed. In the chapter that follows model is being expended from the two to the three types of firms and conditions under which there is the existence of the pooling, the semi-pooling, and the separating equilibrium, are being derived and shown both graphicly and analytically.

THE MODEL WITH TWO TYPES OF FIRMS

Different types of firms have different profitability, π . It is assumed that p represents the probability that a firm's profit is low, $\pi = L$ and that $1-p$ represents the probability that the firm's profit is high, $\pi = H$, where $H > L > 0$. To realize an investment opportunity with the payoff R , the firm needs to find an investor who will invest the sum I . Attractiveness of the project is described with the inequality $R > I(I + r)$, where r represents the investor's alternative rate of return. To compensate for the needed funds, the firm will offer to the investor an equity stake, $s \in [0,1]$, in the aggregate value of the firm after the project's realization, $\pi + R$.

The investor can accept or refuse the offer, but, because the game is played under the condition of information asymmetry, he does not have the information about the firm's profitability. The firm can also decide not to undertake the project. The article will define a perfect Bayesian equilibrium in a signaling game between the firm and the investor. Figure 1 shows the signaling game between the firm and the investor along with the timing and payoffs of the players.

Nature plays the first move and determines a type of firm. The firm knows which type has been determined and has the interval of strategies $s \in [0,1]$ from which one is designated in Figure 1 along with the corresponding information set. If the firm decides to give up the project, the game ends. The investor has two strategies for each offer received by the firm, accept the offer, a , or refuse, r . Payoffs of the players are indicated at the final nodes of the game, left being the payoff of the firm and right being the payoff of the investor.

For the firm it is only rational to offer an equity stake, s , if and only if,

$$\begin{aligned}(1 - s)(\pi + R) &\geq \pi, \\ \pi + R - s(\pi + R) &\geq \pi, \\ R &\geq s(\pi + R), \\ s &\leq \frac{R}{\pi + R}\end{aligned}\tag{1}$$

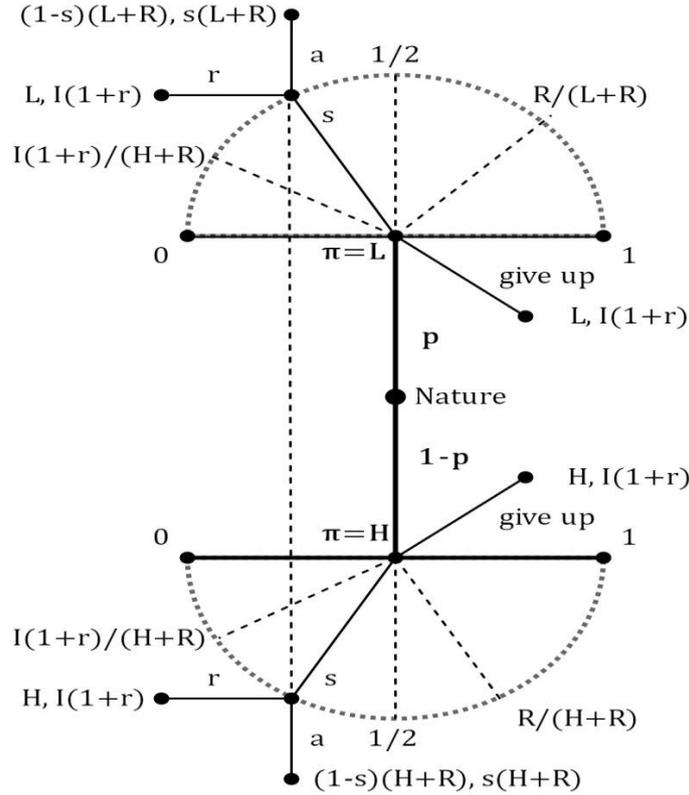


Figure 1. The signaling game of a firm and an investor.

Otherwise, the firm will be at a loss if the investor accepts an equity stake, s , that does not satisfy the equation.

In a signaling game, a Receiver, because of the condition of information asymmetry, interpreters a move played by a Sender as a signal which informs him about a type of a Sender. Therefore, a Receiver's strategy needs to be following a created belief or a probability, about which type could have played the move. For the Receiver's strategy to be a part of the perfect Bayesian equilibrium, the created belief needs to be determined by the Bayesian formula and a strategy of the Sender. Hence, the investor's belief is described with $q = p$, where p stands for the probability by which Nature determines the type of firm or a frequency of the type of firm in a market. If there were no information asymmetry every belief will be equal to 1.

For every offer, s , received by the firm, the investor has a belief, q , that the offer is sent by the L-type of the firm. Then, $1-q$ is the probability that the offer is sent by H-type of the firm and the corresponding payoff of the investor is

$$qs(L + R) + (1 - q)s(H + R) = s \tag{2}$$

If the investor rejects the offer, then his payoff is equal to $I(1+r)$. For the investor, it is rational to accept the offer s , if and only if,

$$s[qL + (1 - q)H + R] \geq I(1 + r),$$

$$s \geq \frac{I(1+r)}{qL+(1-q)H+R} = f(q). \tag{3}$$

The lowest offer which the investor accepts is $s = f(0) = \frac{I(1+r)}{H+R}$, when he is certain that the H-type offered the equity stake. A graph of the function $f(q)$, shown in Figure 2, will be used for a description of the perfect Bayesian equilibrium.

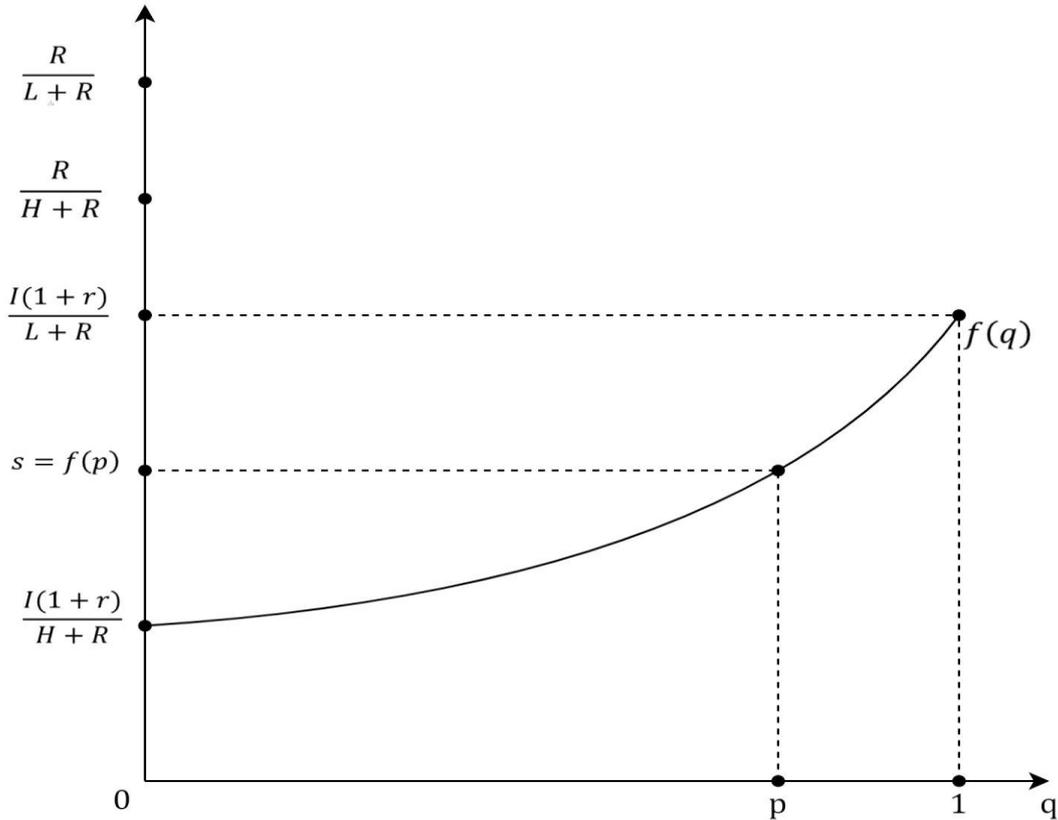


Figure 2. The perfect Bayesian equilibrium of the signaling game of a firm and an investor.

In the perfect Bayesian equilibrium, the firm's strategy needs to be per the criteria, $s \leq \frac{R}{\pi+R}$. The investor's strategy also needs to be under the criteria, $s \geq f(q)$, depending on the created belief, q . The project will be realized only when the firm's offered equity stake is equal to or bigger than the equity stake the investor would accept, $s_F \geq s_I$. Furthermore, depending on the belief, q , the H-type equity share, $s_H = \frac{R}{H+R}$, and the equity share the investor would accept when certain L-typed played the move, $s = f(1) = \frac{I(1+r)}{L+R}$, there can exist a pooling or a separating equilibrium inside the perfect Bayesian equilibrium. In the pooling equilibrium, both types of firms could have played the same move and the signal does not inform the investor about the type of firm.

If $\frac{R}{H+R} \geq \frac{I(1+r)}{L+R}$ then the pooling equilibrium exists for every probability, p , that the firm is L-type. The equilibrium is described with the firm's offer, $s = f(p)$, which the investor accepts, Figure 2. Lower equity stakes, ones that will be better for the firm, the investor does not accept if his belief is still $q = p$.

If $\frac{R}{H+R} < \frac{I(1+r)}{L+R}$ and the investor's belief that the L-type sent the offer is small enough, $p \in \left[0, f^{-1}\left(\frac{R}{H+R}\right)\right]$, then the offer, $s = f(p)$, which the investor accepts is still the description of pooling equilibrium, Figure 3.

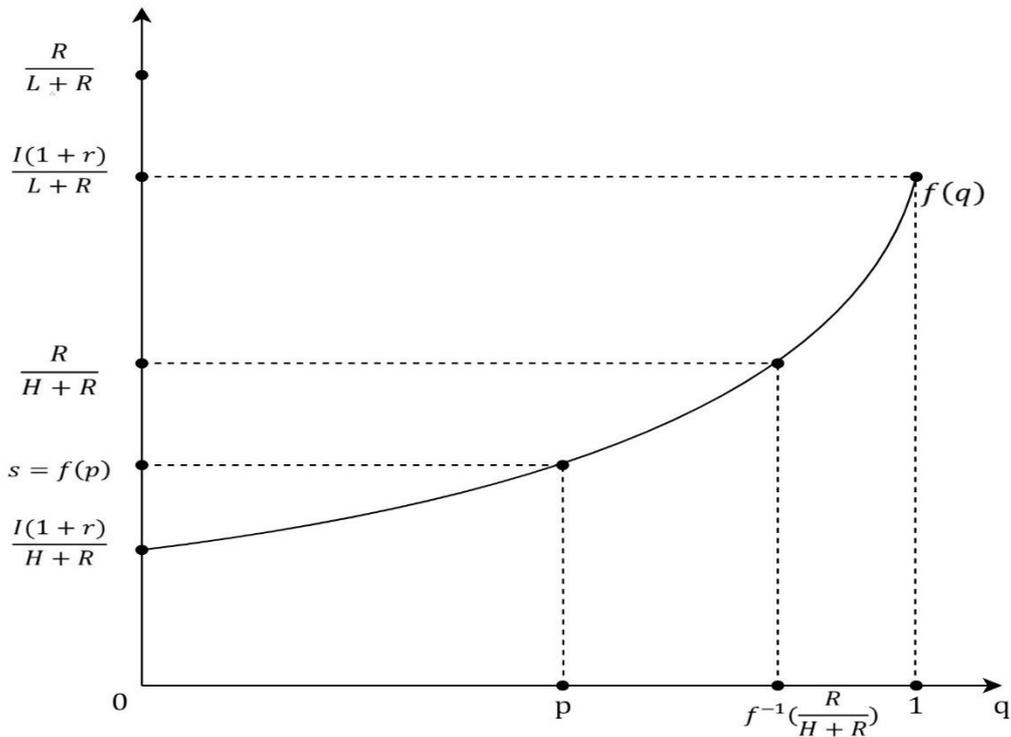


Figure 3. The pooling equilibrium when the L-types probability is small enough.

If $\frac{R}{H+R} < \frac{I(1+r)}{L+R}$ and the investor's belief that the L-type sent the offer is big enough, $p \in \left(f^{-1}\left(\frac{R}{H+R}\right), 1\right]$, then pooling equilibrium does not exist, Figure 4. In that case, exists separating equilibrium in which the L-type offers equity stake, $s_L = \frac{I(1+r)}{L+R}$ which the investor accepts and the H-type offers equity stake, $s_H < \frac{I(1+r)}{L+R}$, which the investor rejects.

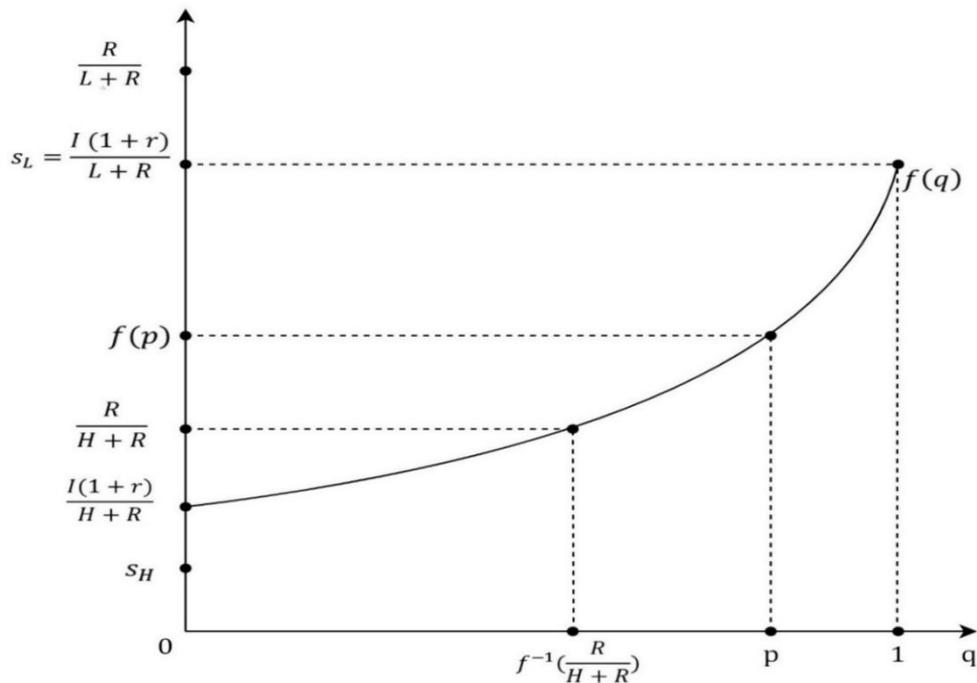


Figure 4. The separating equilibrium when the L-type probability is sufficiently large.

Offers $s \in \langle \frac{R}{H+R}, s_L \rangle$ are not rational for the H-type of the firm so the investor's belief is described with $q = I$ and he will reject them. Offers $s \leq \frac{R}{H+R}$ the investor also rejects the belief described with $q = p$. Offer s_L which the investor accepts for the H-type is not rational and the result is the perfect Bayesian equilibrium. It is important to notice that if $\frac{R}{H+R} > \frac{I(1+r)}{L+R}$, for H-type it is better to offer s_L then s_H and then separating equilibrium does not exist.

Table 1. Conditions under which the project will be realized along with corresponding payoffs.

Ratio	Value of p	Type of equilibrium	Payoffs	Project
$\frac{R}{H+R} \geq \frac{I(1+r)}{L+R}$	$p \in [0, 1]$	pooling	$(1-s)(\pi+R),$ $s(\pi+R)$	realized
$\frac{R}{H+R} < \frac{I(1+r)}{L+R}$	$p \in \left[0, f^{-1}\left(\frac{R}{H+R}\right)\right]$	pooling	$(1-s)(\pi+R),$ $s(\pi+R)$	realized
$\frac{R}{H+R} < \frac{I(1+r)}{L+R}$	$p \in \left[f^{-1}\left(\frac{R}{H+R}\right), 1\right]$	separating	$(1-s_L)(L+R),$ $s_L(L+R)$ or $H, I(1+r)$	partially realized

In the separating equilibrium, for the described values of the ration and the value of p , the project gets realized for both types of firms. However, in the pooling equilibrium, the project gets realized only for the L-type of the firm. In that case, the payoff for the L-type will be $(1-s_L)(L+R)$, $s_L(L+R)$, and the payoff for the H-type will be $H, I(1+r)$.

Even though the game is not modeled in that manner, it is noticeable, when $\frac{R}{H+R} \leq s = f(p)$ holds, that the H-type would have an interest in signaling the investor about the type, in other words, for H-type it would be beneficiary to lower the belief, p , that the firm is L-type because that would mean the realization of the project and the better welfare.

THE MODEL WITH 3 TYPES OF FIRMS

The previous analysis can be expended by adding the M-type of a firm whose profit is $\pi = M$, where $H > M > L > 0$. Therefore, a probability that a firm is the L-type is p_1 , a probability that a firm is the M-type is p_2 , and a probability that a firm is the H-type is $1 - p_1 - p_2$. The signaling game between a firm and an investor in the model of 3 types of a firm has the same structure as the model of 2 types of a firm.

The investor's belief that an offer comes from the L-type, the M-type, or the H-type is described with probabilities q_1 , q_2 and $1 - q_1 - q_2$. If the investor accepts the offer his payoff is

$$q_1s(L+R) + q_2s(M+R) + (1-q_1-q_2)s(H+R) = s[q_1L + q_2M + (1-q_1-q_2)H + R] \quad (4)$$

Otherwise, the investor's payoff is $I(1+r)$. For the investor, it is rational to accept the offer if and only if

$$s[q_1L + q_2M + (1-q_1-q_2)H + R] \geq I(1+r),$$

$$s \geq \frac{I(1+r)}{q_1L+q_2M+(1-q_1-q_2)H+R} = g(q_1, q_2). \quad (5)$$

The graph of function $g(q_1, q_2)$ is shown in Figure 5.

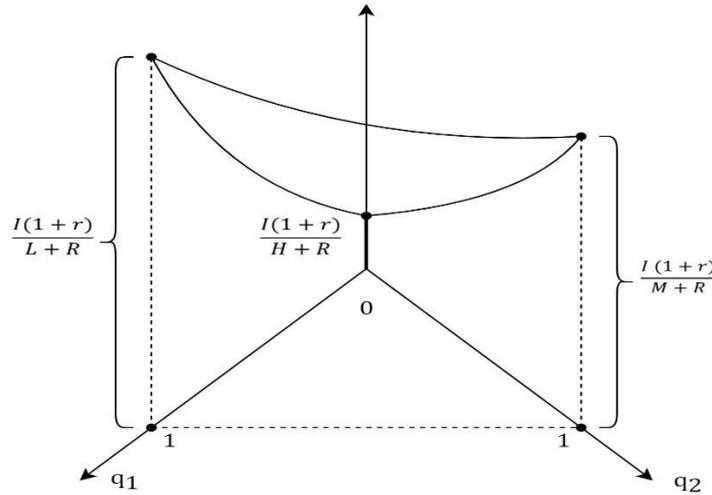


Figure 5. The graph of function $g(q_1, q_2)$.

The function $g(q_1, q_2) = \frac{I(1+r)}{H+R-q_1(H-L)-q_2(H-M)}$ is strongly increasing and the following inequalities hold

$$g(0,0) = \frac{I(1+r)}{H+R} < g(0,1) = \frac{I(1+r)}{M+R} < g(1,0) = \frac{I(1+r)}{L+R}. \quad (6)$$

The equation of the level line of the function $g(q_1, q_2)$ is

$$\begin{aligned} g(q_1, q_2) &= \bar{s}, \\ \frac{I(1+r)}{H+R-q_1(H-L)-q_2(H-M)} &= \bar{s}, \\ H + R - q_1(H - L) - q_2(H - M) &= \frac{I(1+r)}{\bar{s}}, \\ q_1(H - L) - q_2(H - M) &= H + R - \frac{I(1+r)}{\bar{s}} \end{aligned} \quad (7)$$

Interval of \bar{s} is $\left[\frac{I(1+r)}{H+R}, \frac{I(1+r)}{L+R} \right]$ and for boundary values level sets are points. Figure 6 shows the level line for the function $g(q_1, q_2)$.

The absolute value of the slope of the level curve is $\frac{H-L}{H-M}$ and it is bigger than 1.

The following cases should be observed:

- 1.) case: If $\frac{R}{H+R} \geq \frac{I(1+r)}{L+R}$ then the firms offer, $s = g(p_1, p_2)$, is the description of the pooling equilibrium where the investor's belief is described with $q = (q_1, q_2) = (p_1, p_2)$ and the investor accepts the offer. Lower offers, the ones that will be better for the firm, the investor will not accept if his belief does not change. The pooling equilibrium then exists for every probability distribution of the firm's types.
- 2.) case: If $\frac{R}{H+R} < \frac{I(1+r)}{L+R}$ and $g(p_1, p_2) \leq \frac{R}{H+R}$ then the firms offer, $s = g(p_1, p_2)$, which the investor accepts, is still the description of the pooling equilibrium.
- 3.) case: If $\frac{R}{H+R} < \frac{I(1+r)}{L+R}$ and $g(p_1, p_2) > \frac{R}{H+R}$ then the pooling equilibrium does not exist.

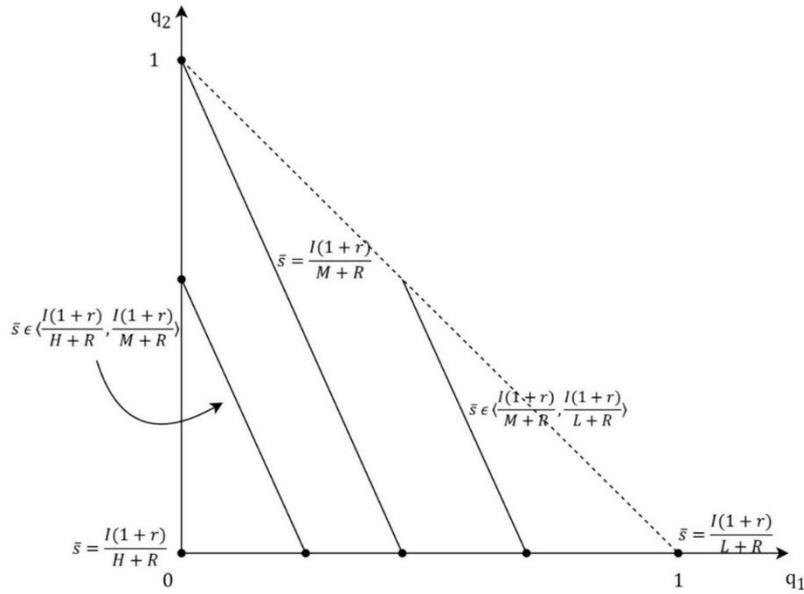


Figure 6. The level line for the function $g(q_1, q_2)$.

The next subcases should be observed:

3.a) subcase: If $\frac{R}{H+R} \geq \frac{I(1+r)}{L+R}$ then in the perfect Bayesian equilibrium, the H-type of the firm offers the equity stake, $s_H < \frac{I(1+r)}{H+R}$, which the investor rejects. The next two types offer the same equity stake, $s = g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right)$ which the investor accepts because his belief is determined by the Bayesian formula and the firm's strategy, Figure 7.

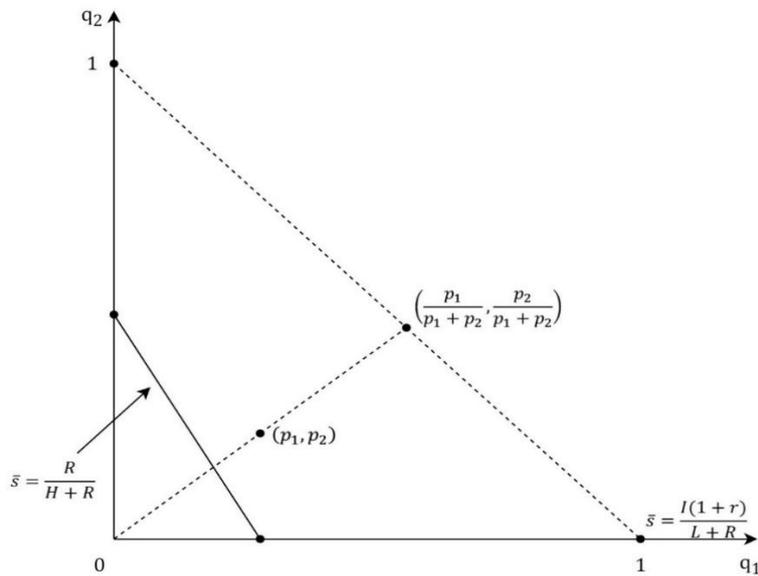


Figure 7. The semi-pooling equilibrium of the model with 3 types of a firm.

For equity stake offers, which are not included in the firm's strategy, the investor's belief is determined by the Bayesian formula and the principle that lower shares could only be offered by the type of the firm for whom it is rational to offer the lower share. Therefore, for the offers, $s \in \left(\frac{R}{H+R}, g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right)\right)$, which would put the L-type and the M-type in the better position, the investor's belief is described with $q = \left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right)$, and he rejects the offers.

The equity stake offers, $s < \frac{R}{H+R}$, the investor also rejects because then his belief is $q = (p_1, p_2)$ and $g(q) = g(p_1, p_2) > \frac{R}{H+R} \geq s$.

It is also important to notice that for the H-type there is no rational offer which the investor would accept.

3.b) subcase: If $\frac{R}{M+R} < \frac{I(1+r)}{L+R}$ and $g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right) \leq \frac{R}{M+R}$ then still the H-type offer, $s_H < \frac{I(1+r)}{H+R}$, which the investor rejects, and the L-type and the M-type offer, $s = g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right)$, which the investor accepts, are the description of the perfect Bayesian equilibrium, Figure 8. The perfect Bayesian equilibrium exists for the probabilities which are described within the shaded area excluding the level line when $\bar{s} = \frac{R}{H+R}$.

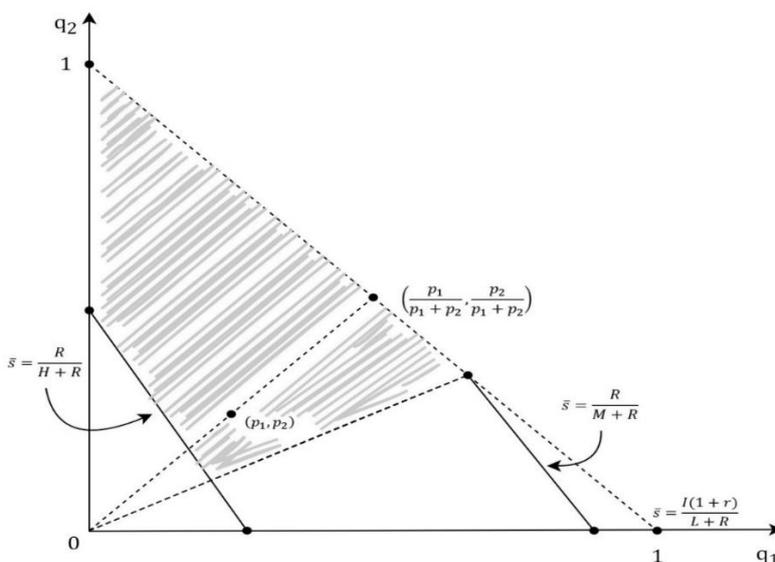


Figure 8. The semi-pooling equilibrium for the certain probability distribution of the firm's types.

3.c) subcase: If $\frac{R}{M+R} < \frac{I(1+r)}{L+R}$ and $g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right) > \frac{R}{M+R}$, then equity stake offers, $s_H < \frac{I(1+r)}{H+R}$, $s_M < \frac{I(1+r)}{M+R}$ and $s_L = \frac{I(1+r)}{L+R}$, are the description of the perfect Bayesian equilibrium, where the investor accepts only the offer from the L-type, s_L . If $s_H \neq s_M$, then the game has got the separating equilibrium, Figure 9.

If $s \in \left(\frac{R}{M+R}, s_L\right)$, then the investor's belief is $q = (1, 0)$, $g(q) = \frac{I(1+r)}{L+R} = s_L > s$ and the investor rejects the offer.

If $s \in \left[\frac{R}{H+R}, \frac{R}{M+R}\right] \setminus \{s_H, s_M\}$ then the investor's belief is $q = \left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right)$,

$g(q) = g\left(\frac{p_1}{p_1+p_2}, \frac{p_2}{p_1+p_2}\right) > \frac{R}{M+R} \geq s$ and the investor rejects the offer.

If $s \leq \frac{R}{H+R}$ and $s \notin \{s_H, s_M\}$ then the investor's belief is $q = (p_1, p_2)$, $g(q) = g(p_1, p_2) > \frac{R}{H+R} \geq s$ and the investor rejects the offer, which is in accordance with the perfect Bayesian equilibrium.

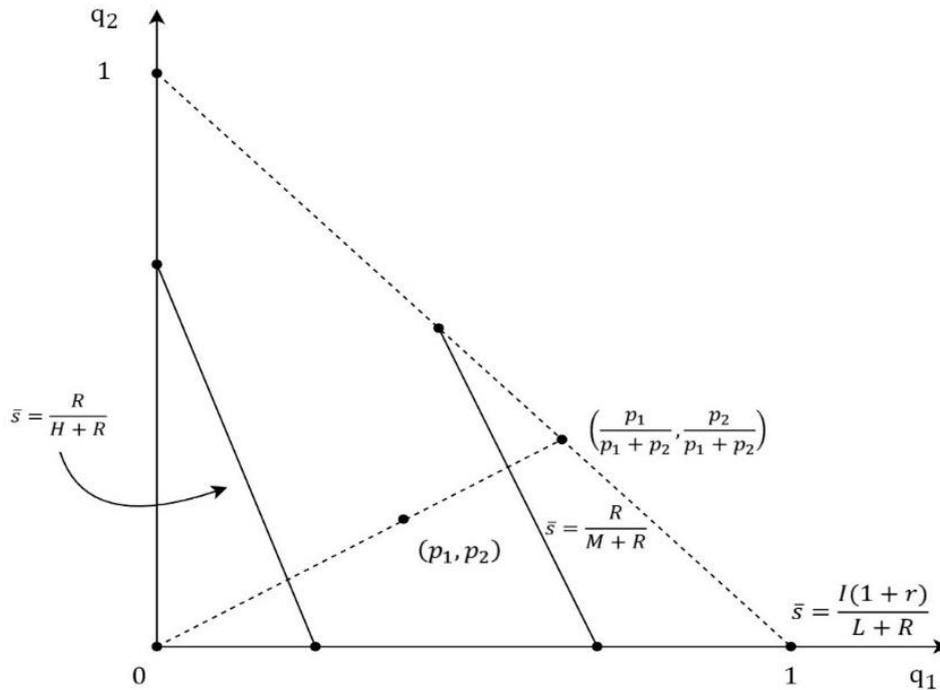


Figure 9. The separating equilibrium of the model with 3 types of a firm.

CONCLUSION

Firms that do not have enough funds to take advantage of a valuable investment opportunity, need to find an investor, whose funds can secure the realization of the project. Both, a firm and an investor, need to decide under the condition of information asymmetry because the investor does not know the firm's profitability. The relationship is modeled as a signaling game and this article is revising Gibbon's model with two types of firms along with the analysis of the derived result.

The article is precisely defining which small enough probabilities of the L-type of a firm will cause the existence of the pooling equilibrium. Also, the article defines which big enough probabilities of the L-type of a firm will cause the existence of the separating equilibrium. The conditions are stated under which a separating or a pooling equilibrium does not exist. The revision of Gibbon's results is complemented with the graphical representation of the game, which is showing the timing and the payoffs of the game. The description of equilibrium is done by defining a function, along with its graph, for the lowest equity stake that would be accepted by the investor who is rational and has created a belief about a firm's profitability.

The signaling model is expanded adding one more type of a firm and also is the set of possible equilibriums. The function for the lowest equity stake that would be accepted by the investor who is rational and has created a belief about a firm's profitability is shown graphically in a three-dimensional space, along with its properties. The analysis of the level lines of the function enables to differentiate cases and to describe conditions under which there is an existence of a pooling, a semi-pooling, and a separating equilibrium. Analytical description of the conditions complements the graphical description which gives clear visibility of the share of the financially attractive projects which do not get realized. The limitation of the article is that it only analyzes an equity stake offered in exchange for the funds needed for the project's realization. Future research may include the analysis of more types of firms and different types of contracts, between a firm and an investor, which will reduce the negative economic consequences occurring because of the number of financially attractive projects that do not get realized.

ACKNOWLEDGMENTS

I. Vrankić was the mentor of P. Skoko's diploma thesis. This article is a continuation of the research in which three types of firm are introduced and it differs significantly from the diploma thesis in terms of approach and derived results.

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ANALYSIS OF SURFACE CURVATURE INFLUENCE ON 3D SCANNING ACCURACY OF DENTAL CASTINGS

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ABSTRACT

The main goal of this study is determining the influence of surface curvature on 3D scanning accuracy of dental castings. The hypothesis is that 3D scanning errors occur on the geometry (surfaces) of a higher curvature on the dental anatomy. Ten dental castings (five mandibular and five maxillar) were 3D scanned with four different dental 3D scanners. As a reference device Atos Core industrial 3D scanner was used. Using a qualitative-quantitative approach of dividing every tooth in three areas (OS – occlusal surface, CSB – crown surface buccal side, CSP – crown surface palatal side) and observing the frequency of maximal deviation for each area a deviation map was obtained, which shows on what area, are the biggest deviations and in which frequency they emerge. In total 160 teeth were analysed. To conclude, 3D scanning errors occur more frequently on the geometry (surfaces) of a higher curvature on the dental anatomy. Future work suggests conducting a full numerical analysis to find a correlation between the accuracy of 3D scanned teeth surface and a surface curvature. Comparing the 3D scanning deviation to the calculated curvature of the surface could unveil which curvature is hard to 3D scan and generates errors.

KEY WORDS

surface curvature, 3D scanning, dental casting, accuracy

CLASSIFICATION

JEL: Z39

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INTRODUCTION

A dental impression is a copy of an oral structure used to make a dental restoration, denture, or dental guide. Surgical (dental) guides are medical fixtures that are used to determine the direction and depth of drilling when placing dental implants [1, 2]. An accurate impression is crucial for making dental guides that fit the patient's dental anatomy well. Errors in manufacturing the impression can cause mechanical and biological complications due to incorrect implant positioning. In the research [3] it is stated that deviations of all technical parameters in the design of dental guides are not yet known, which ultimately may result in a total deviation of up to ± 2 mm.

To ensure consistency, i.e. a good fit between the anatomy of the patient and the dental guide, there are numerous impression techniques today, and the two basic ones are:

- Digitalization of oral anatomy is performed by 3D scanning of the patients cast. Although more time consuming and less accurate than direct imaging with an intraoral 3D scanner [4], this procedure still represents the gold standard in dentistry [5],
- Direct digitalization of oral cavity with oral 3D scanner.

Numerous studies document precision and comparison of precision between the two of the above methods [6-8]. At the same time, one study [6] states the positions on the teeth (premolars and molars) where the largest differences in the acquired data are between the digitization of the casting and the direct intraoral 3D image.

Although there are numerous papers investigating the influence of different parameters on the making of the patient's oral cavity model [5, 6, 8] nowhere is attention paid to the geometry being digitized. There is one study in which it is superficially stated which types of teeth are digitized better than others, i.e. it is stated that the largest errors in 3D scanning occur at the positions of the premolars and molars [6].

Based on the above, it can be concluded that there is a need to obtain such information, i.e. to do a research that would result in specific information on which dental surfaces due to the shape and curvature produce errors (inaccuracy) due to digitization by 3D scanner.

From research [9] and also from experience we know that the curvature and complexity of the surface affects the accuracy of digitization, i.e. it is directly related to the resolution of the scanner and the size of the object to be digitized. As oral surfaces can be very complex, it is assumed that errors due to digitization occur, i.e. are always grouped at the same places. This may be related to scanner accessibility and the greater likelihood of sulcular and interdental areas containing larger data based on interpolation [10]. This ultimately means that some surfaces are digitized better and some worse (errors occur). In dental implantology, it is essential that the surfaces on which the dental guides rest are accurately digitized to fit well.

HYPOTHESIS FORMULATION

Hypothesis: Digitalization errors occur on the geometry (surfaces) of a higher curvature on the dental anatomy. To confirm this, a comparative analysis of casting measurements was performed for available laboratory scanners and one intraoral 3D scanner. The ATOS CORE industrial 3D scanner was used as a reference device, with which all others were compared.

Because dental surfaces are complex, the problem is approached by observing each tooth separately and is further divided into three areas: the occlusal surface (OS), the tooth crown surface on the buccal (CSB), and the tooth crown surface on the palatal side (CSP), (Fig. 1). CSB and CSP areas represent low curvature surfaces, and OS represents the high curvature surface.

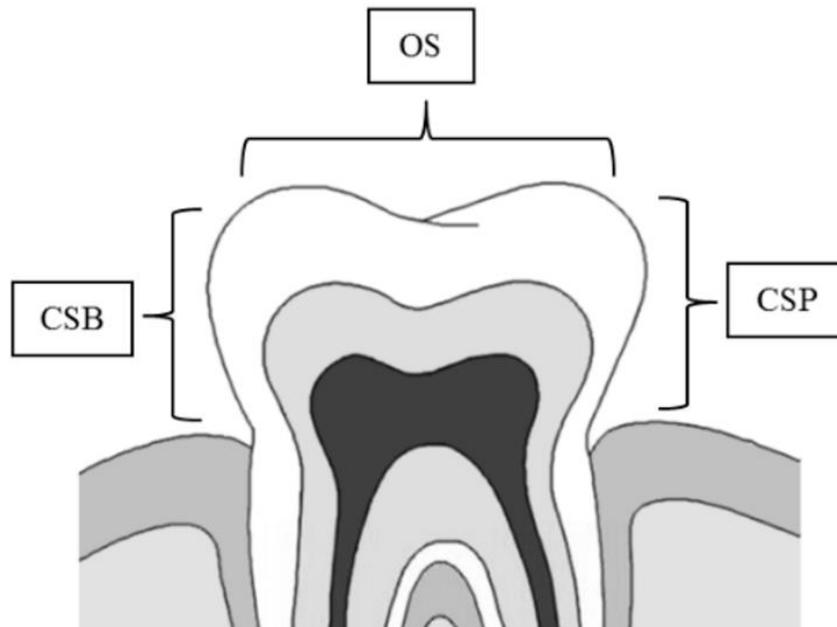


Figure 1. A schematic view of the low (CSB, CSP) and high (OS) curvature dental surfaces.

In order to determine on which surfaces the errors occur for each tooth, the largest positive and the largest negative deviations were read and one of the already mentioned codes was assigned to it. By observing the frequency of occurrence of the largest deviation (positive and negative), it can be determined in which of the three areas the maximum deviation by position and area of each tooth most often occurs.

MATERIALS AND METHODS

Ten dental castings with full dentition (five mandibular and five maxillary) made of Class IV (Interstone) dental plaster were made from “dummy” jaws. Dental castings were digitalized with an industrial 3D scanner ATOS CORE, Gom company certified by PTB (The National Metrology Institute of Germany) and NIST (National Institute of Standards and Technology, USA). 3D scanning was performed in the measurement laboratory in controlled temperature conditions $22 \pm 1^\circ\text{C}$ and relative humidity $55\% \pm 10\%$. Table 1 shows the basic characteristics of the reference device.

Table 1. ATOS CORE 3D scanner basic characteristics.

Number of cameras, pcs	Measure area, mm	Work distance, mm	Resolution, mm	Sensor dimensions, mm	Operational temperature, °C
2	135 × 100	170	0,01	206 × 205 × 64	+5°C up to +40°C

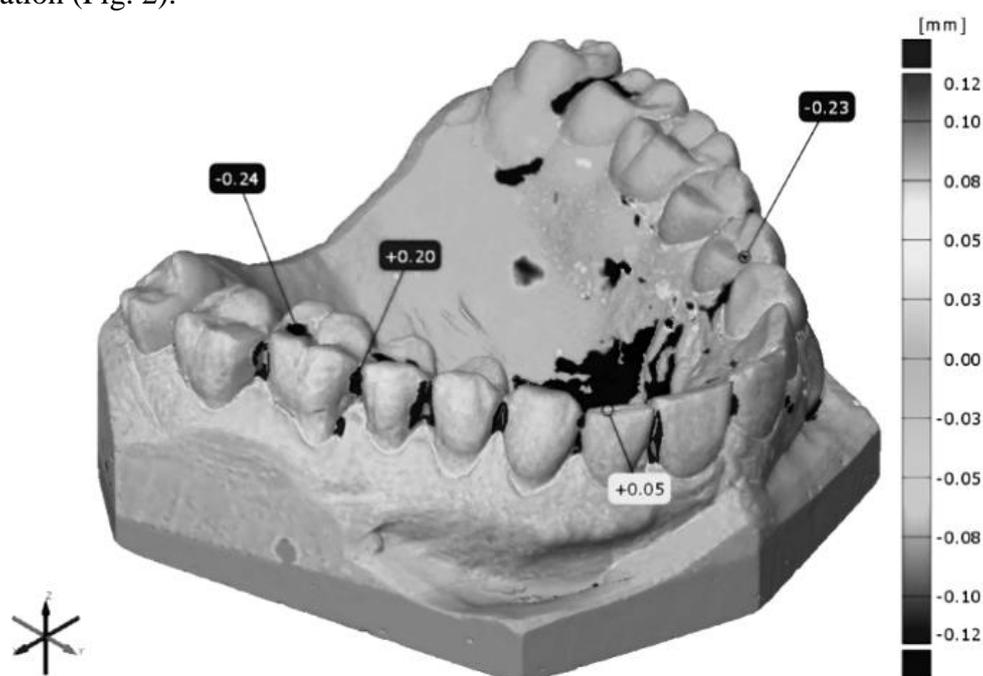
The castings were then digitalized with two dental laboratory scanners, one intraoral and one industrial 3D scanner. The castings were digitalized in standard laboratory conditions under which they are normally used in practice. In Table 2 the basic characteristics of the used 3D devices are listed.

After digitalization, all models were saved in .stl file format. For comparison with reference models, the industrial software package GOM Inspect (GOM GmbH, Germany) was used, which is used for analysis of 3D measurement data from structured light or laser scanners, three-coordinate measuring devices (CMM) and other measuring systems.

Table 2. Basic characteristics of used 3D scanners.

	3D scanner			
	Comet5	S900	Swing	Trios3
Manufacturer	Steinbichler	ZirkonZahn	DOF	3Shape
Type	industrial	laboratory (dental)	laboratory (dental)	intraoral
Number of cameras, pcs	1	3	2	2
Measure area, mm	444 × 330 × 250	115 × 78	–	–
Scanning technology	structured light	structured light	structured light	structured light
Model coating	n/a	n/a	n/a	n/a
Point distance, mm	0,32 mm	< 0,01mm	< 0,01 mm	–
Resolution, MPx	1,4 MPx	High	1,3 MPx	High

GOM software is used in product development, quality control and production. It is certified by NIST and PTB. Reference and controlled 3D models were inserted into GOM Inspect and superimposed with the “best-fit” method. After matching, the dimensions were compared using the “Surface Comparison on CAD” tool. The result of the comparison is a color graphic representation (Fig. 2).

**Figure 2.** Surface comparison of reference and measured dental casting.

The positive deviation is shown in red and is defined as the geometry that is larger, i.e. located above the reference surface. The negative deviation is shown in blue and is defined as the geometry located below the reference surface. The green colour represents areas without deviations.

In addition to the defined surfaces on the teeth (OS, CSP, CSB), the areas where two teeth touch (meet) were also observed. This area is very interesting because due to the narrow interdental spaces, a scanner error occurs when recording it [10]. As for the previous measurement, the largest positive and negative deviation was read for each interdental space, and it was assigned the corresponding code where the deviation occurred. The sign “P” indicates the palatal (lingual) side, and the sign “B” the buccal (cheek) side.

RESULTS

After comparison with the reference model and reading the positive and negative deviations for each casting, the map was obtained which shows in which frequency (percentage) the maximum deviations appear on each tooth and in which area. Also the average positive and negative deviation for each of the areas CSB, CSP, OS was calculated.

For each mandibular and maxillary casting digitalized with the same dental scanner, a statistical t-test was performed to see if there was a statistically significant difference in scanner error between the mandible and the maxilla. The assumption is that there should be no difference. The t-test was conducted in the Matlab 2012a software package (Mathworks).

The null hypothesis was tested that the deviation frequencies for maxilla and mandible were independent random samples from normal distributions with equal means and equal variances ($\alpha = 0,01$). The results of all t-tests turned out null (0). This shows that for each 3D scanner there is no statistically significant difference between the mandible and maxilla. Therefore, the results are shown in a summarized table (Table 3) by tooth type for a particular 3D scanner.

Table 3. Results sorted by tooth type for a particular 3D scanner.

	Positive deviations					Negative deviations			
	Scanner	Area	f, %	\bar{x} , mm	SD, mm	Area	f, %	\bar{x} , mm	SD, mm
Molar	Comet5	OS	100 %	0,289	$\pm 0,039$	OS	100 %	0,265	$\pm 0,028$
	S900	OS	67,5 %	0,118	$\pm 0,078$	OS	97,5 %	0,107	$\pm 0,091$
	Swing	OS	80 %	0,131	$\pm 0,075$	OS	95 %	0,118	$\pm 0,101$
	Trios3	OS	65,6 %	0,184	$\pm 0,089$	OS	62,5 %	0,149	$\pm 0,086$
Premolar	Comet5	OS	97,5 %	0,285	$\pm 0,057$	OS	100 %	0,271	$\pm 0,033$
	S900	OS	52,5 %	0,087	$\pm 0,055$	OS	95 %	0,048	$\pm 0,018$
	Swing	OS	65 %	0,123	$\pm 0,062$	OS	95 %	0,064	$\pm 0,054$
	Trios3	OS	56,3 %	0,122	$\pm 0,065$	OS	68,8 %	0,060	$\pm 0,013$
Canine	Comet5	CSP	80 %	0,138	$\pm 0,042$	OS	90 %	0,222	$\pm 0,042$
	S900	CSB	70 %	0,048	$\pm 0,018$	OS	65 %	0,033	$\pm 0,008$
	Swing	CSB	85 %	0,064	$\pm 0,022$	CSP	40 %	0,040	$\pm 0,026$
	Trios3	CSP	56,3 %	0,067	$\pm 0,023$	CSP	50 %	0,058	$\pm 0,026$
Incisor	Comet5	CSP	62,5 %	0,151	$\pm 0,069$	OS	100 %	0,244	$\pm 0,047$
	S900	CSB	77,5 %	0,055	$\pm 0,023$	OS	57,5 %	0,034	$\pm 0,013$
	Swing	CSB	90 %	0,064	$\pm 0,019$	OS	40 %	0,043	$\pm 0,017$
	Trios3	CSP	81,3 %	0,077	$\pm 0,017$	OS	50 %	0,073	$\pm 0,015$

Further in the text are the results of the deviation when imaging the interdental spaces of the teeth for a particular 3D scanner (Table 4 and Table 5).

Table 4. Positive deviations – interdental spaces.

Scanner	Area	f, %	\bar{x} , mm	SD, mm
Comet5	B	36,20 %	0,342	± 0,161
	P	63,10 %	0,339	± 0,160
	No deviations	0,80 %	0,000	± 0,000
S900	B	69,20 %	0,140	± 0,078
	P	30,00 %	0,101	± 0,071
	No deviations	0,80 %	0,000	± 0,000
Swing	B	80,00 %	0,267	± 0,042
	P	18,50 %	0,242	± 0,075
	No deviations	1,50 %	0,000	± 0,000
Trios3	B	54,80 %	0,178	± 0,080
	P	42,30 %	0,152	± 0,084
	No deviations	0,00 %	0,000	± 0,000

Table 5. Negative deviations – interdental spaces.

Scanner	Area	f, %	\bar{x} , mm	SD, mm
Comet5	B	0,00 %	0,00	± 0,00
	P	0,00 %	0,00	± 0,00
	No deviations	100,0 %	0,00	± 0,00
S900	B	54,60 %	0,114	± 0,059
	P	45,40 %	0,115	± 0,062
	No deviations	0,00 %	0,00	± 0,00
Swing	B	32,30 %	0,132	± 0,090
	P	31,50 %	0,109	± 0,087
	No deviations	35,40 %	0,00	± 0,00
Trios3	B	49,00 %	0,105	± 0,063
	P	51,00 %	0,061	± 0,037
	No deviations	0,00 %	0,00	± 0,00

DISCUSSION

The null hypothesis was accepted. Digitalization errors occur more frequently on the geometry (surfaces) of a higher curvature on the dental anatomy. By analyzing the summarized results for each group of teeth (Table 3, 4 and 5) we can state the following:

- Molar – positive and negative deviations for each 3D scanner in more than 65 % of cases deviations are present on the occlusal surfaces (OS) with an amount that greatly exceeds the expected deviation specified by the manufacturer. The amount of 100 % incidence for Comet5 can be explained by the insufficient resolution of the 3D device. The 3D device Trios3 has the lowest incidence of 65,6 % for positive and 62,5 % for negative deviations, which can be explained by the fact that this is the only intraoral scanner, so errors compared to the other devices also occur in a higher percentage on other surfaces (CSB, CSP).
- Premolar – similar to the molar for each 3D scanner, deviations are present mostly on the occlusal surfaces (OS). The high incidence rates of 97,5 % for positive and 100 % for negative deviations in Comet5 scanners can also be attributed to the lower resolution of the device. For the other three devices, the percentage for positive deviations is in the range of 52,5 % to 65 % with a mean deviation value that greatly exceeds the accuracy declared by the manufacturer. Negative deviations in the other three devices range from 68,8 % to 95 % on the occlusal surface (OS). It can be concluded that the incidence of the largest negative deviation is higher than the positive one, but the mean value is much lower.

- Canine – positive deviations for all observed devices are deposited on the palatal and buccal surfaces (CSP, CSB). The highest frequency is present in Comet5 scanner (80 %) on the palatal side, while the lowest of 56,3 % is present in Trios3 scanner also on the palatal side. The other two scanners have amounts of 70 % (S900) and 85 % (Swing) on the buccal side. Negative deviations are deposited on the occlusal (Comet5 and S900) and palatal surfaces (Swing and Trios3). There is no significant difference in the mean values between the positive and negative deviations.
- Incisor – positive deviations in the incisors occur in the highest frequency on the palatal and buccal surfaces (CSB, CSP). Negative deviations are again deposited on the occlusal surfaces, i.e. the incisal edge in all 3D devices, in the range from 40 % to 100 %. The consequence of the accumulation of negative deviation on the incisal edge, as well as the canines, indicates errors in matching and connecting separate images of the 3D scanner, which artificially “shrinks” the final surface, i.e. the geometry is smaller than in reality. This is probably due to sudden changes in the incisor geometry.
- Interdental positive deviations – with all 3D devices, positive deviations are noticeable in the interdental spaces, which are many times larger than the nominal resolution of the device. Positive deviations are equally present on both sides (buccal and palatal), except for the Swing 3D scanner where 80 % of the errors are grouped buccally. This may be due to the influence of digitization methods. The casting “swings” during digitalization, so the surfaces on the palatal side are recorded first, and then on the buccal side, which causes errors in matching individual images.
- Interdental negative deviations – are present in all 3D devices except Comet5 scanner, which can be explained by lower resolution which causes “filling and closing” of narrow spaces. Weaker resolution is not able to detect such sudden changes in geometry. Considering other devices negative deviations are equally distributed on buccal and palatal area and are of the same order of magnitude as positive ones.

CONCLUSION

In this preliminary study surface curvature influence on 3D scanning accuracy of dental castings was analysed. After comparing digitized dental castings to the reference model it was concluded that for all observed 3D scanners errors occur on various surfaces but most of them are located on surfaces with higher curvature.

During 3D scanning special attention should be paid to the digitalization of the occlusal surfaces of the molars and premolars, because the error frequencies are highest there. Also, when supporting dental guides, occlusal surfaces should be avoided if possible in molars and premolars.

In canines and incisors, the situation is similar because both positive and negative deviations are similar in values. Negative deviations can be taken as a reference, which, although small in size, also appear to a greater extent on the occlusal surface (incisal edge). The conclusion is that the reliance of dental guides on the incisal edge should be avoided.

Interdental spaces, due to their complex geometry, pose a challenge in 3D scanning because they generate errors, so if they are crucial, special attention should be paid to them when digitalization with a 3D scanner. The conclusion is that interdental spaces should be avoided when designing and supporting dental guides.

Future work suggests finding a numerical correlation between the accuracy of 3D scanned teeth surface and a surface curvature. Although the 3D scanned objects are represented in .stl file format which is a discrete representation of a continuous surface, mathematical operations

like calculating surface curvature are possible. Comparing the 3D scanning deviation to the calculated curvature of the surface could unveil which curvature is hard to 3D scan and generates errors.

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