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Teleworking and sustainable behaviour in the context of COVID-19: the case of Lithuania

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ABSTRACT
COVID-19 played a significant role in the spread of telework worldwide, changing people's lives and behaviour. The paper aims to identify how teleworking affected the sustainable behaviour of employees during the COVID-19 pandemic. The research design applies a multi-method approach, combining systematic and comparative scientific literature analysis and a semi-structured interview. The authors of the paper present the theoretical conceptual model, which illustrates links between teleworking during the COVID-19 pandemic and the sustainable behaviour of employees. The results of empirical research revealed that teleworking during the COVID-19 pandemic changed employee behaviour in economic, environmental and social dimensions. Positive changes were identified due to reduced commuting and shopping; decreased costs for transport, food, clothing, and beauty services; better access to healthy and nutritious food; better opportunities for professional development. On the contrary, costs for home energy and household waste increased. Adverse effects on employees' physical and mental health have been identified due to teleworking and COVID-19. Despite the identified negative effects, employees would like to continue teleworking even after the pandemic.

KEY WORDS
teleworking, sustainable behaviour, COVID-19

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Introduction

The COVID-19 virus outbreak at the beginning of 2020 changed how people live and work and has brought unprecedented changes to the global economy and work (Irawanto et al., 2021). Most of these changes and a series of proactive interventions, such as social distancing, lockdown, confinement, and quarantine, were adopted to prevent the spread of COVID-19 (Nguyen, 2021; Freire González & Vivanco, 2020). Governments applied lockdowns and social distancing policies that disrupted ordinary daily life and in-person participation in activities

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(ILO, 2020; Hatayama et al., 2020; Mouratidis & Papagiannakis, 2021; Olde Kalter et al., 2021; Christopoulos et al., 2021). New challenges and opportunities for business innovation have emerged, including organising and designing work (Loia & Adinolfi, 2021). Emergency related to COVID-19 forced companies compatible with teleworking modalities to choose remote activities where possible (Tokarchuk et al., 2021; Loia & Adinolfi, 2021).

As stay-at-home measures entered into force, people were asked to stay at home and work from home or to telework as much as possible (Olde Kalter et al., 2021; Christopoulos et al., 2021; Irawanto et al., 2021; Chong et al., 2020). The World Health Organization suggested that governments and organisations worldwide implement teleworking as a work innovation to protect employees' health while continuing economic activities (Irawanto et al., 2021; Minh Hieu Nguyen, 2021). Organisations sent their employees home, creating conditions for the most extensive mass teleworking experiment in history (ILO, 2020; Loia & Adinolfi, 2021). This pushed the incidence of telework to an unprecedented tipping point (Chong et al., 2020). In most countries, the importance and frequency of engaging in telework significantly increased during COVID-19; it has become a dominant professional experience for many organisations and employees, relocating workplaces to employees' homes (Olde Kalter et al., 2021; Mouratidis & Papagiannakis, 2021; Music et al., 2022; Christopoulos et al., 2021; Chong et al., 2020; Raišienė et al., 2020).

Research works show that teleworking is gaining momentum in many countries worldwide, with the number of teleworkers increasing every year (Raišienė et al., 2020; Czerniawska & Szydło, 2021; 2022). In the past, numerous studies have explored the potential of teleworking and how it relates to organisations and employees, sometimes with positive and negative results (Christopoulos et al., 2021). Although teleworking was already on the rise prior to the COVID-19 pandemic, the sudden shift to telework in public health and safety interests has most certainly accelerated this phenomenon (Music et al., 2022).

Telework and the COVID-19 pandemic play an important role in human behaviour. Schmidt et al. (2021) believe that the corona pandemic could represent an opportunity for the transition towards sustainable behaviour and, thus, a window of opportunity for sustainability. Sustainable behaviour has become an expression that is commonly used and is often substituted with other popular expressions, such as pro-ecological, environmentally friendly, eco-friendly, and green behaviour (Čiarnienė et al., 2020). Sustainability has different dimensions; however, scientists generally agree that the focus is on the economic, environmental and social dimensions. Based on Chae (2021), sustainable behaviour reflects the use of goods and services responding to the basic needs of society and future generations, bringing a better quality of life while reducing the use of natural resources, waste emissions and pollutants.

Many recent studies examined different aspects of teleworking in the context of COVID-19. For example, Hatayama et al. (2020), Nguyen (2021), Chong et al. (2020), and Tokarchuk et al. (2021) investigated jobs' amenability to working from home and the determinants that affect working from home. Advantages and disadvantages of telework were analysed by Moos et al. (2006), Irawanto et al. (2021), Nguyen (2021), Loia and Adinolfi (2021), Olde Kalter et al. (2021). Irawanto et al. (2021) examined the relationship between work–life balance and work stress. Mouratidis and Papagiannakis (2021) analysed changes in the importance and frequency of engaging in online activities before and during COVID-19. Raišienė et al. (2020) and Irawanto et al. (2021) focused on employees' attitudes towards teleworking and employee satisfaction. Olde Kalter et al. (2021) examined the changes in teleworking during the lockdown and the intention to change commuting behaviour after COVID-19.

Some studies analysed sustainability issues related to telework. For example, Moos et al. (2006) analysed telework in terms of environmental sustainability. Čiarnienė et al. (2018) analysed how flexible work arrangements could contribute to sustainable development. Čiarnienė et al. (2020) investigated how employees relate to sustainable behaviour across generations, genders and different modes of education. Freire-González and Vivanco (2020) investigated pandemics and the environmental rebound effect, Loia and Adinolfi examined teleworking as an eco-innovation for sustainable development, and Music et al. (2022) concentrated on socially sustainable practices. Brzustewicz and Singh (2021) analysed the COVID-19 pandemic changes in consumer behaviour towards a healthier and more sustainable direction. Zambrano-Monserratea (2020) has highlighted the negative indirect effects of the pandemic on sustainable behaviour.

Although topics of teleworking and sustainable behaviour have been widely analysed by the scientific community during the past years, there is a gap in scientific studies examining the sustainable behaviour

of teleworkers in the context of the pandemic. This inspired the authors of this article to analyse issues related to the sustainable behaviour of teleworkers during COVID-19. The study aims to fill this gap by identifying how teleworking affected the sustainable behaviour of employees during the COVID-19 pandemic. The research design applies a multi-method approach, combining systematic and comparative analysis of scientific research works and a semi-structured interview.

1. Theoretical background

Teleworking is not a new phenomenon; it has existed for several decades. The concept of working from home was first put forward in the 1970s as a new alternative to performing work from different locations (office, home, or another place) using technological assistance (Irawanto et al., 2021). Teleworking was seen as an essential measure for reducing daily travel and coping with traffic jams and environmental pollution (Christopoulos et al., 2021). Many organisations have long offered telework as a form of flexible work arrangement to enable employees to better manage increasing work and family demands (Čiarnienė et al., 2018; Chong et al., 2020).

Speaking about the terminology, teleworking comes in the literature under various names. An array of terms is used to describe working outside the workplace, such as telework, telecommuting, remote work, distance work, home-working, e-work, flexplace, and electronic cottage (Tokarchuk et al., 2021; Nguyen, 2021; Loia & Adinolfi, 2021). Many studies have used the term "teleworking" (mostly by European and Asian scholars) interchangeably with "telecommuting" (preferred by American and Canadian authors) (Loia & Adinolfi, 2021; Nguyen, 2021). The essence of teleworking includes two main aspects: geographical dispersion and employees' dependence on Information and Communication Technologies (ICT) (ILO, 2020; Raišienė et al., 2020; Loia & Adinolfi, 2021). According to literature sources, teleworking can be defined as an alternative work arrangement for employees to conduct work elsewhere, outside the employer's locations, for at least a part of their work schedule, using ICT to cooperate and communicate with others inside and outside the organisation (ILO, 2020; Tokarchuk et al., 2021).

Compared to occasional teleworking under normal circumstances and under a typical telework arrangement, when an employee splits work time between working at the office and working from an off-site location, teleworking during the COVID-19 pandemic was "far more challenging because it is mandatory, rather than voluntary, and full-time, rather than part-time or occasional" (ILO, 2020). According to the Practical Guide of ILO (2020), switching from office-based working to teleworking was not simple or smooth for organisations and their employees, especially for those with limited prior experience with teleworking. This guide emphasises difficulties related to organisational culture and management resistance, the lack of appropriate IT tools and devices, skills and training resources, health and safety guidelines for the home office, and data secu-

Tab. 1. Factors influencing telework

Factors/variables		Description
Employee-related	Sociodemographic characteristics	Individual characteristics are of great importance to characterise who desires to and/or who is fit for teleworking (gender, age, education, income)
	Household characteristics	The presence or the number of children, especially young age, drives a choice for telecommuting
	Attitudes and preferences towards telework	Employees desiring teleworking; employees actually adopting telework when they have opportunities
	Frequency	Number of times employees actually telework within a particular period, such as a week
	Previous experience	Experience in using teleworking can be a significant factor affecting the choice and the frequency of telework
Organisation- related	Type of organisation and work	Type of organisation and job sector, the opportunities to telework
	Organisational readiness	Organisational and technological readiness: employee options to telework. Managers' ability to manage remote teams
	Burdensome commute	One-way distance between home and workplace and travel options

Source: elaborated by the authors based on ILO (2020), Nguyen (2021), Olde Kalter et al. (2021), Tokarchuk et al. (2021), Loia and Adinolfi (2021).

rity concerns and privacy issues (ILO, 2020). Based on ILO (2020), Nguyen (2021), Olde Kalter et al. (2021), Tokarchuk et al. (2021), and Loia, Adinolfi (2021), Table 1 presents the main factors influencing the prevalence of telework and its effectiveness.

As Table 1 shows, factors can be arranged into two groups: employee-related and organisation-related. From an employee's perspective, socio-demographic and household characteristics are very important. Fewer people than expected found telework good for them due to individual characteristics or home and family situations (Loia and Adinolfi, 2021). According to research conducted by Hatayama et al. (2020), women, college graduates, and salaried and formal workers have jobs that are more amenable to working from home than an average worker. Educational attainment is also strongly linked to telework amenability (Hatayama et al., 2020; Olde Kalter et al., 2021). Speaking about age, older workers are less likely to have jobs amenable to telework (Hatayama et al., 2020). Employees with a higher income level tend to be more interested in teleworking (Nguyen, 2021; Olde Kalter et al., 2021). The presence or the number of children, especially young age, drives a choice for telecommuting (Nguyen, 2021). Experience in using the internet and teleworking can also be a significant factor affecting the choice and the frequency of telework (Nguyen, 2021). On the part of the organisation, the portion of jobs amenable to teleworking determine the size of the workforce that can work from home (ILO, 2020). Other organisation-related important factors should also be mentioned: the type of organisation and work, organisational and technological readiness (basic IT infrastructure, virtual

Tab. 2. Main advantages and disadvantages of teleworking through sustainability dimensions

Sustainability dimensions	Advantages	Disadvantages
Economic	• Less rush-hour commutes, • Reduced consumption of time and fuel, • Avoidance of lost time and cost of commuting, • Ability to work according to own working rhythm to accomplish the most, • Increased job performance and productivity, • Reduction in expenditures on restaurant meals, • Decreased external childcare hours and costs, • Less consumer-driven lifestyle, • Decreased costs for clothing, • Reduced external laundry and dry-cleaning	• The lack of a good and quiet workplace at home, • Increase in work-related purchases: equipment, paper, furniture at the telework site, • Increased costs for electricity, communication, heating, air conditioning, • Slow or patchy internet and technology tools at home can cause productivity and work satisfaction decrease, • Data security concerns and privacy issues
Social	• Autonomy of time management, increased personal control over work schedule, • Flexibility in balancing work and personal life, • Possibility to work from home in cases of sickness, • Fewer disruptions to the office environment and other employees, • Decreased employee stress due to less formal supervisor in the workplace, • Higher levels of job satisfaction, • Increased morale, engagement, and commitment, • Reduced employee burnout and turnover intentions, • Reduction in car use and an increase in cycling and walking, • A shift to healthier diets, • Positive effect on health outcomes, • Better possibilities for education and training, • Potential to increase social wellbeing, • Positive impact in terms of social inclusion (e.g., women during pregnancy, with young children, temporarily recovering from an accident, etc.)	• Absence of social contacts, social isolation, • Technostress and technology addiction and overload, which increases fatigue and irritability, • The ergonomics of home furniture may not be optimal for prolonged teleworking, • Prolonged sedentary behaviour, working in one position over long periods increases the risk of health problems, • Increased consumption of alcohol and other recreational or performance-enhancing drugs, • Higher risk of technology-enabled violence, cyberbullying and harassment, including domestic violence, • A risk of burnout and feeling left out, • Blurred boundaries between work and personal life, • Increased work hours, disturbed balance between work and free time, • Difficulties in concentrating on the job, especially when living with young children
Environmental	• Reduced daily travel and congestion problems, • Reduced consumption of time, fuel and energy, • Reduced air pollution and climate change, • Higher recycling and waste reduction, • Less consumer-driven lifestyle, less clothing, • Reduced external laundry and dry-cleaning, • Decreased food-related environmental impacts	• Increased home energy use, • Increased wastes disposed of through domestic systems

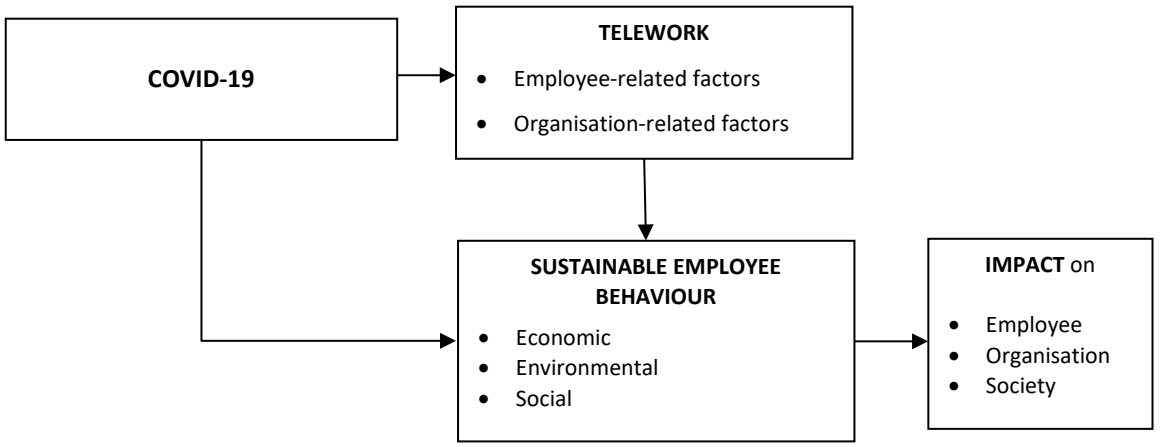

Fig. 1. Theoretical conceptual model illustrating links between teleworking during the COVID-19 pandemic and sustainable behaviour of employees

platforms), and managers' ability to manage remote teams (Tokarchuk et al., 2021). Another factor worth mentioning is the burdensome commute. The longer the distance, the greater the likelihood and frequency of teleworking and having positive attitudes toward telework (Nguyen, 2021). According to Olde Kalter et al. (2021), car users are less likely to adopt teleworking than frequent public transport users.

Interest in teleworking has been fuelled by its flexibility and resulting benefits. It can be a win–win strategy for all stakeholders, such as employees, employers, and societies (Čiarnienė et al., 2018; Raišienė et al., 2020; Irawanto et al., 2021; Nguyen, 2021). Also, the transition to teleworking has indirect consequences for the transformation towards more sustainable behaviour. Sustainable behaviour can be defined as a personal concern about sustainability issues (Elhoushy & Lanzini, 2021) or as decisions that are simultaneously economically, ecologically, and socially responsible (Moos et al., 2006; Villa Castaño et al., 2016; Czerniawska & Szydło, 2021). It is a set of deliberate and effective actions that result in the conservation of natural and social resources; it encompasses pro-ecological, frugal, altruistic and equitable behaviours (Tapia-Fonllem et al., 2017). These behaviours allow the conservation of the natural environment, cost reduction, and the protection of the integrity of society. Based on research works by Čiarnienė et al. (2018), Irawanto et al. (2021), Nguyen (2021), Loia and Adinolfi (2021), ILO (2020), Olde Kalter et al. (2021), Moos et al. (2006), Brzustewicz and Singh (2021), Xin et al. (2020), Zambrano-Monserratea (2020), Music et al. (2022), and Schmidt et al. (2021), Table 2 provides the main advantages and disadvantages of teleworking through sustainability dimensions. Benefits and traps are presented from an employee perspective.

Scientific literature shows that sustainable behaviour encompasses several different aspects, such as more moderate use of energy and water, minimisation of emissions and waste, less food buying and consumption, sustainable fashion, a relative increase in bike use and in the coverage of distances by foot, urban gardening, promoting better access to healthy, safe, and nutritious foods. This also leads to cost savings, positive health and safety issues and social changes.

However, teleworking during the COVID-19 pandemic is far more challenging and has more traps that should be empirically investigated. Based on the conducted systematic and comparative literature analysis, the authors present a theoretical conceptual model which illustrates the influence of telework on sustainable employee behaviour in the context of the COVID-19 pandemic (Fig. 1).

Telework and the COVID-19 pandemic influenced sustainable employee behaviour that can be assessed through economic, environmental and social dimensions. In turn, sustainable employee behaviour impacts employees, their organisation and society as a whole.

2. Research methods

To explore the links between teleworking during the COVID-19 pandemic and the sustainable behaviour of employees, qualitative research was used in the form of semi-structured interviews based on open-ended questions. According to Kallio et al.

(2016), a semi-structured interview is a versatile and flexible method that ensures two-way communication between the interviewer and the participant and allows for improvisation by asking further questions based on the answers received. It is expected that the answers will be as comprehensive and open as possible, formulated and presented by the research participants and reflecting their views (Gaižauskaitė & Valavičienė, 2016).

Sample size. Achieving data saturation is the most commonly employed concept for estimating sample size in qualitative research (Guest et al., 2020). Different authors recommend different sample sizes, which can range from 5 to 60 (Guest et al., 2020; Hennink & Kaiser, 2022). According to Hennink & Kaiser (2022), data saturation can be achieved even with a small sample, such as 9–17 interviews. In this study, data saturation was determined after twelve interviews. Therefore, twelve respondents participated in the study, including eight women and four men, ages ranging from 28 to 60. Participants were selected using targeted sampling based on the most typical areas of telework, such as education, financial activities, trade, tourism, entertainment and leisure, catering, public administration, and health services. Based on a scientific literature analysis, the agenda for the interview guide was developed for the following areas: telework organisation, sustainable employee behaviour, and intentions after COVID-19.

Ethical principles were followed during the semi-structured interview: the researcher's opinion was not advised or insulted, the interview plan was followed, and the respondent was certain that the question was well understood and was given enough time to provide answers. The principle of voluntariness was followed: the decision to participate in the research was made by interviewees, and they were not influenced. Interviewees were provided with information about the research and the purpose of the study. The principle of confidentiality was also observed: if the respondent requested, the data and information obtained were private and anonymous and not disseminated. Codes I1, I2 ..... I12 were assigned to each research participant to ensure the preservation of privacy.

Participants were contacted to organise a convenient day and time for the interview; interviews were conducted live and remotely via the Zoom platform in January–March 2022 in the Republic of Lithuania. The average interview duration was 45 min. The interviews were recorded, translated and transcribed. The data obtained during the interview were processed by interpreting, systematising, analysing, and categorising the responses.

3. Research results

Evidence citations are used to support the view presented by participants by categories and subcategories. The first category — organisation of telework during COVID-19. This category covers three subcategories: 1) duration/frequency of telework, 2) workplace and its installation, and 3) expectations for the future/intentions after COVID-19. Supporting statements are presented in Table 3.

Summarising the answers, during the pandemic, most informants spent a large part of their time working remotely, especially in the education, financial and tourism sectors. Almost all informants indicated problems related to the installation of a remote workplace and its convenience for work. In terms of expectations for the future, informants stressed the desire to continue teleworking, even after the pandemic.

The second category — economic behaviour when teleworking in the context of COVID-19. This category covers three subcategories: 1) efficient use of resources and costs, 2) labour productivity, and 3) additional costs. Supporting statements are presented in Table 4. From the data in the table, it can be concluded that costs for transport, food, clothing, and beauty services decreased, but costs for heating, electricity, medical and disposable protective equipment increased. Opinions differed on labour productivity. Most of them mentioned the positive effects of teleworking, mainly due to time saved for travel and preparation for work. Others also saw a decline in productivity due to a lack of motivation and control.

The third category — environmental behaviour when teleworking during COVID-19. This category covers two subcategories: 1) use of natural resources and 2) waste management. Supporting statements are presented in Table 5.

In this category, informants highlighted the positive behavioural changes associated with the use of natural resources because of reduced commuting and shopping. In the field of waste management, positive changes have been observed in relation to nutrition, clothing and sorting. However, negative aspects were also noted: the increase in household waste due to both teleworking and protection against COVID-19.

The fourth category — social behaviour when teleworking during COVID-19. This category covers

Tab. 3. Organisation of telework during COVID-19

Subcategory	Statements
Duration/ frequency	"At the beginning of the pandemic (more than a year), I worked only remotely, then, up to now, 70 % of the time I work from home and 30 % in the workplace" [I1] "At the beginning (about 1.5 years), I worked only remotely, then, up to now, 70 % of the time I work remotely and 30 % of the time at the workplace" [I2] "At the beginning of the pandemic (about one year), I worked only remotely, then 50/50, now 30/70" [I3] "At the beginning of the pandemic (about 1.5 years), I worked only remotely, then, until now, 80/20 [I5] "Most of the time, I worked remotely" [I4] [I6] "Part of the time, we did not work at all, later, it was mixed, but mostly we worked at the workplace" [I7] "It was allowed to choose; some people worked only from home, I worked from the office workplace two days a week" [I8] "I worked in a mixed way: both at the workplace and remotely" [I9], [I12] "The work schedule has not changed fundamentally" [I1] "The work schedule has extended" [I2] "It was necessary to make changes in the work schedule to combine the work at the workplace and remote work" [I3]
Workplace, its installation	"The employer did not provide the equipment necessary for telework" [I1] "Lack of software" [I2] "Insufficient internet speed" [I3], [I10], "Slow internet made me crazy" [I6] "My home computer does not support some programs" [I1], [I12] "I didn't have a quiet place working from home" [I8], [I11] "My home furniture was not comfortable to work" [I9] "I faced data security issues" [I7], [I12]
Expectations / intentions after COVID-19	"After COVID-19, I expect to telework as much as possible" [I1], [I10] "After COVID-19, I expect to telework similarly as during the pandemic" [I2] "I expect to work from home after COVID-19 also" [I3], [I12] "I would like to work from home at least two days a week" [I5] "I miss the "live" work and contacts with co-workers, so I'd like to work in a mixed way" [I6]

Tab. 4. Economic behaviour when teleworking in the context of COVID-19

Subcategory	Statements
Efficient use of resources, costs	"Since I go to work much less often, much less time is spent on trips, and therefore less money is spent" [I1] "No more traffic problems during peak hours" [I2], [I11] "Since I didn't have to drive, I saved money on fuel" [I3], [I9] "Nutrition costs have decreased somewhat due to less buying and cooking at home" [I1] "Significantly reduced the need to replenish the wardrobe" [I2] "Reducing the need for beauty services by working from home saved me money" [I3] "At the beginning of the pandemic, beauty services were sorely lacking; some things I learned to do myself" [I4] "When working at home, I use all resources (water, electricity) more sparingly" [I5], [I8] "My purchases are thought out in advance, I don't buy what I don't need/have not planned" [I6] "I saved money due to less shopping" [I10]
Labour productivity	"The time saved for commuting allowed to increase productivity" [I1] "Work from home is more productive for me" [I4] "I could work according to my agenda, so I was more productive" [I8] "I was able to start working practically as soon as I got out of bed, saving a lot of time to get ready for work" [I2] "What I did in an hour in the workplace, I do in three hours remotely" [I3] "The number of various meetings, sometimes completely unnecessary, has increased" [I5] "Due to reduced motivation, I was not so productive" [I7] " When there's no control, I don't always work as hard as I can" [I9]
Additional costs	"I use more electricity and heating because I work from home" [I1], [I2] "The ordering food from cafes has increased, the costs increased as well" [I10] "Online purchases of work-related goods have increased" [I11] "The need for and cost of medicines has increased" [I3] "There were additional costs for masks" [I6], [I9] "I spent quite a lot on protective equipment (disinfectant, masks)" [I4]

Tab. 5. Environmental behaviour when teleworking during COVID-19

Subcategory	Statements
Use of Natural Resources	"Since I didn't have to drive, I saved money on fuel while not polluting the environment" [I2] "Items suitable for use (clothes, shoes, books, furniture...) I give up for secondary use" [I5] "I always use a reusable bag for shopping" [I8] "When working at home, I use water and electricity more sparingly" [I4] "I go shopping less often, I use disposable bags less" [I1] "Less excess food" [I6]
Waste management	"I used up my accumulated food supplies" [I3] "I don't throw away food" [I1] "There was a chance to get creative and update my old clothes" [I7] "I had to give out a lot of clothes to charity because I gained weight" [I3] "I've noticed that a lot of people carry clothes in textiles, there is not even space in containers" [I5] "I don't shy away from shopping in second-hand clothing stores" [I1] "I spend more time/attention on waste sorting" [I8] "I always composted and sorted" [I1] "I return beverage containers for recycling" [I1], [I8] "During quarantine, I cleaned the closet and gave away unnecessary clothes" [I4] "I noticed an increase in home wastes disposed of" [I2] "There has been an increase in waste at home, especially paper and plastic packaging from food" [I10] "Additional waste was generated due to the use of disposable protective equipment" [I4] "I was having a problem getting rid of used masks" [I6]

Tab. 6. Social behaviour when teleworking during COVID-19

Subcategory	Statements
Work–life balance	"I have no small children; my husband worked in the workplace; therefore, I had no problems" [I1] "With children who study at home, it is impossible to work remotely normally" [I2] "It is difficult to share the available space and equipment with family members" [I4] "No boundaries between work and rest time" [I6] "It was difficult to balance work and rest" [I3] "Work and rest unbalanced" [I8] "I pay more attention to my hobbies and gardening" [I1] 'Due to the closure of various activities, leisure has become limited" [I10] "I missed sports events" [I12]
Positive health effects	"Since masks are required in public transport, I try to go to work on foot when possible" [I1] "During the pandemic, I cook more at home and eat healthier food" [I4] "I spend much more time walking outside and so on" [I2] "Morning exercise habit formed" [I3] "I engage in sports remotely" [I9], [I10]
Negative health effects	"I avoided going to beauty salons for fear of contracting COVID-19" [I7] "As a result of self-activity, I faced unpleasant consequences (condition of hair, nails, skin)" [I8] "Mental health deteriorated" [I10] "Health problems from long sitting appeared" [I7] "Emotional state deteriorated" [I12] "Remote work makes me move less" [I1] "There was a lack of medical services at the beginning of the pandemic" [I6] "After a long sitting in an awkward workplace, my back started to hurt" [I11] "The use of disinfectant has caused skin problems" [I1] "Breathing problems have been caused by disinfectant and constant wearing of masks" [I5]
Qualification	"My employer organised various remote training and sometimes free of charge" [I1] "Employer-provided opportunities to raise qualification remotely for free" [I6] "I attend various training events and seminars remotely" [I1], [I2] "More opportunities for advanced training" [I4] "At the beginning of the pandemic, there was a severe lack of access to training" [I7] "I attended conferences remotely" [I1], [I3] "While attending remote seminars, I was able to re-listen to the recordings" [I8] "I have participated in international events remotely" [I9]

three subcategories: 1) work–life balance, 2) health effects and 3) qualification. Supporting statements are presented in Table 6.

In the area of social behaviour, informants were ambiguous about work–life balance. For many, this has caused problems, especially for those raising young and school-age children; others felt rather comfortable. Some informants have missed a wider range of leisure activities due to very limited entertainment options during the pandemic. In the field of health, various opinions were expressed regarding movement, diet, and physical and emotional state, but in general, it can be said that the health effects were negative. Speaking about qualifications, the informants noted more positive changes in the field of professional development, mentioning the opportunities to participate more often and at a lower cost or even free of charge.

Summarising the whole study, teleworking in the context of COVID-19 has brought positive changes in sustainable behaviour: in terms of economic behaviour, it brought cost savings; environmental — sustainable use of natural resources; and social — increased opportunities for professional development. However, the increase in teleworking due to COVID-19 has also led to the following negative aspects: increased costs for electricity, heating, medicine and security (economic behaviour); increased household waste (environmental behaviour); problems of work–life balance, deterioration of physical and emotional health (social behaviour).

4. Discussion and conclusions

Due to COVID-19, pandemic organisations sent their employees home, creating conditions for the most extensive mass teleworking experiment in history. Compared to occasional teleworking under normal circumstances, teleworking during the COVID-19 pandemic was far more challenging because, in many cases, it was mandatory and full-time. COVID-19 has had a clear impact on the spread of teleworking in the entire world, and this has affected human behaviour in the context of sustainability. Although the topics of teleworking and sustainable behaviour have had great interest from the world scientific community during the past decade, there is a gap in research works that examine the sustainable behaviour of teleworkers in the context of the COVID-19 pandemic. The primary objective of this study was to fulfil this gap by identifying how teleworking during the pandemic affected the sustainable behaviour of employees.

From a theoretical perspective, this research contributed by the main factors influencing the prevalence of telework and its effectiveness, the main advantages and disadvantages of teleworking through sustainability dimensions and the theoretical conceptual model illustrating links between teleworking during the COVID-19 pandemic and sustainable behaviour of employees. Sustainable employee behaviour that can be assessed through economic, environmental and social dimensions is influenced by telework and the COVID-19 pandemic. In turn, sustainable employee behaviour impacts employees, their organisation and society as a whole.

From an economic perspective, the authors of this research agree with the findings by Brzustewicz and Singh (2021), stating the positive changes related to a decrease in costs for transport, food, clothing, and beauty services. On the contrary, costs for home heating, electricity, medical and disposable protective equipment increased. An increase in home energy use confirmed research results by Moos (2006) and Loia and Adinolfi (2021). Research disclosed different opinions on labour productivity. While most interviewees mentioned the positive effects of teleworking, mainly due to time saved for travel and preparation for work, others stated a decline in productivity due to a lack of motivation and control. Such ambiguous opinions partly confirmed the findings provided by Loia and Adinolfi (2021). From an environmental perspective, positive behavioural changes have been identified with decreased use of natural resources because of reduced commuting and shopping. These results are in line with the findings by Loia and Adinolfi (2021) and Music et al. (2022) that teleworking can improve environmental sustainability.

In the field of waste management, positive changes have been observed in relation to nutrition, clothing and sorting. Similar to findings by Zambrano-Monserratea (2020), negative aspects were disclosed as an increase in household waste due to both teleworking and protection against COVID-19.

The study results from a social perspective were ambiguous about work–life balance. Results revealed that for many parents with young and school-age children, this had caused difficulties in working from home, but others felt comfortable. In the case of Loia and Adinolfi (2021) and Nguyen (2021), the family situation effects and the presence of young children on work and life balance were also confirmed. In the

field of health, various opinions were expressed regarding movement, diet and physical and emotional state. In some cases, similarly to Schmidt et al. (2021), an increase in coverage of distances by foot was identified. Research confirmed the findings by Music et al. (2022) that teleworking and the pandemic contributed positively to social sustainability, promoting better access to healthy and nutritious food. In general, the health effects were more negative than positive. This matches the results by Loia and Adinolfi (2021), indicating that teleworking has negative consequences for physical and emotional health. The main reasons for this were poor ergonomics of home furniture, prolonged sedentary behaviour, a disturbed balance between work and free time, lack of medical services at the beginning of the pandemic, and the use of protective measures against COVID-19. Speaking about professional development, positive changes were identified due to better opportunities for personal and professional development at a lower cost or even at no charge.

In terms of expectations, the empirical study disclosed the desire of research participants to continue teleworking even after the pandemic. This is in line with the findings by Irawanto et al. (2021), Music et al. (2022), and Olde Kalter et al. (2021) that even after the pandemic, this current global job norm would continue. The desire to continue teleworking and ensure work productivity is inseparable from a quiet workplace equipped with the necessary hardware and software, stable internet connection, and data protection measures to minimise job-related stress and insecurities.

The research opens a space for discussion and future scientific contributions in the areas of teleworking and sustainable behaviour. The findings of this study can be useful for international readers, scientists, and business leaders. It can suggest guidelines for further research in different countries with the purpose of examining the role of teleworking towards sustainable behaviour of employees across different countries.

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Global trends of the research on COVID-19 risks effect in sustainable facility management fields: a bibliometric analysis

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ABSTRACT
This study used bibliometric analysis to investigate global research trends regarding the effect of COVID-19 risks in sustainable facility management fields. Between 2019 and 2021, the Scopus database published 208 studies regarding the effect of COVID-19 risks on sustainable facility control fields. VOSviewer software was used to analyse the co-occurrence of all keywords, and Biblioshiny software allowed getting the most relevant affiliation using the three-field plot. The results show the contribution by authors from 51 countries, and 73 keywords were identified and organised into six clusters, such as the effect of COVID-19 risks on human health, supply chain in construction projects and industry, disaster risk management in a changing climate, sustainable supply chain benchmarking, facility management and quality control, and, finally, sensitivity analysis & decision-making.

KEY WORDS
sustainable, facility management, benchmarking, risk management, COVID-19, bibliometric analysis

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Introduction

Monitoring and controlling sustainable projects through facility management benchmarking concepts could reduce many risks and enable corrective actions to be taken promptly (Elmualim et al., 2012). Creating sustainable environments is an issue addressed by the Facility Management (FM) discipline in a multidisciplinary and integrative way (Becker, 1990; Alexander, 2003). FM plays an essential role in creating a sustainable environment, as it is a practice that ensures effective operational management of buildings (Aaltonen et al., 2013; Shah, 2007). Therefore,

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FM can continuously improve building performance through low or no-cost maintenance, retrofits, and operation strategies combined with proactive operational control and maintenance (Finch & Zhang, 2013).

Concerning the built environment, FM considers the design, maintenance, improvement, and adaptation of buildings and assets over time in the most cost-effective manner (BIFM, 2012). The built environment has several types of residential and commercial buildings, including healthcare, industrial, governmental, educational, agricultural, religious, etc. FM can measure customer satisfaction to support its services, reflecting the requirements related to performance satisfaction and productivity (Alexander, 2003). FM has been a leader in maintaining the facilities' environmental sustainability performance (Shah, 2007). According to Elmualim et al. (2012), facility managers align their practices with social, environmental, and economic ideas of sustainability. However, they are bound by time, the lack of basic information to execute sustainability policies, and the lack of senior management commitment to the sustainability agenda (Elmualim et al., 2012).

Altonen et al. (2013) asserted that sustainable facility management services are given a key role in reducing a company's overall environmental impact through their direct and indirect effects on building environmental performance measures and on readily available data required for green management. Therefore, FM is essential to the planning, construction, and operation of sustainable facilities that are resource-efficient in terms of energy and natural resources (Shah, 2007). As mentioned earlier, the contribution of FM is of paramount importance to the planning and operation of the most resource-efficient and maintainable sustainable buildings (Aaltonen et al., 2013).

Facilities Management Benchmarking (FMB) allows organisations to compare aspects of performance, identify differences, find alternative approaches, evaluate improvement opportunities, implement change, and monitor results. Benchmarking is referred to as "the art of discovering, in an exceedingly completely legal and ideal way, how others do something better than you" (Meng & Minogue, 2011).

The Construction Industry Institute (CII) defined benchmarking as a scientific process of measuring performance against recognised leaders to work out best practices that result in superior performance when adapted and utilised (CII, 1995). Benchmarking could be a multistep process that enables a company to check aspects of performance, identify differences, explore alternative methods, evaluate opportunities for improvement, implement change, and monitor results. Benchmarking was first introduced in the United States of America in the 1990s (Tasopoulou & Tsiotras, 2017) to check the functions and operations of a corporation with those of another organisation to get an external standard. The external criterion can assess the quality and cost of internal processes and explore opportunities for improvement (Alstete, 1995).

Benchmarking concentrates on internal or external measurement (Poister, 2003). In selecting the external measurement, the company either makes direct rapprochement with competitors within the industry or measures other organisations outside its immediate purview. The standard benchmarks for facilities are flexibility, efficient use of space, maintenance management, a secure environment, and value for money. Internally, facility management benchmarking should emphasise business performance or business-related issues (Atkin & Brooks, 2000). Pettersen et al. (1996) identified five distinct stages: planning, research, observation, analysis and adaptation.

The successful implementation of normative benchmarking is reflected in numerous publications coping with the concept, application, and limitations (Macneil, 1994; McNair, 1992). Since the 1990s, there has been significant interest in benchmarking in manufacturing, construction, and other service industries. In 1993, the United States Army Corps of Engineers (USACE) conducted a study to assess project delivery for a federally funded environmental restoration programme using standards and metrics. The researchers selected specific typical performance metrics (e.g., cost growth, schedule growth, planning phase cost factor, design phase cost factor) from those developed by the Building Industry Institute. The study assessed the flexibility of the environmental management programme to implement projects. Additionally, USACE researchers self-evaluated whether the program design goals were achieved. They also addressed customer concerns about O&M costs by calculating the particular cost divided by the estimated cost. USACE researchers found that Corps has improved the delivery of environmental management projects (EMP) because cost and schedule growth trends have shown a consistent decline (Siddiqi, 2004). Konchar and Sanvido (1998) compared cost, schedule, and quality measures on a sample of

351 building construction projects delivered in line with the three most often used project delivery methods: construction at risk, design-build (DB), and design–bid–build (DBB). The researchers concluded that design-build (DB) project delivery provides significant advantages in cost and schedule. It also produced equally and sometimes more desirable quality performance than at-risk construction management.

In 2020, the COVID-19 pandemic struck the entire world. It became a public health emergency that represented a source of professional concern and a high risk to several sectors, including the construction industry. The American Industrial Hygiene Association (AIHA; 2020) has classified COVID-19 as a brand-new construction hazard. Similarly, the European Union Commission as a Group 3 biohazard known to infect humans, which is additionally an occupational health and safety concern (Franklin et al., 2020), has classified COVID-19. According to AIHA (2020), the risk of contracting COVID-19 infection in the construction sector increased rapidly due to the nature of construction work that requires the proximity of workers and sharing of ordinary workplaces, such as elevators, lunch break areas, and sanitation complexes.

Chigara and Moyo (2021) explored factors influencing the delivery of optimum health and safety on construction projects during the COVID-19 pandemic in Zimbabwe. The researchers used factor analysis to reveal nine factors: change and innovation, monitoring and enforcement, production, access to health information and services, on-site facilities' management associated with well-being, risk assessment and mitigation, job security, financing, cost, etc. The findings highlighted the need for social dialogue among construction stakeholders to support initiatives that would enhance the delivery of health and safety in construction projects to workers during the pandemic.

Amoah and Simpeh (2020) used a qualitative study of construction professionals in facilities in South Africa to identify challenges to implementing COVID-19 H&S measures. The main factors that have influenced the implementation of COVID-19 safety measures were spacing requirements, low-risk perception of COVID-19, the supply of inaccurate information, insufficient knowledge of COVID-19, and the supply of poor Personal Protective Equipment (PPE). Zheng et al. (2020) demonstrated that the lack of knowledge and non-compliance with certain COVID-19 safety practices contributed to the spread of COVID-19 in the construction industry in China. In the USA, Hatoum et al. (2021) analysed worker complaints data from OSHA and concluded that the main factors were the inadequate implementation of public and specific COVID-19 health and safety provisions and inadequate (PPE) for workers.

COVID-19 made some terminology more common in everyday life, such as social distancing, self-isolation, and quarantine, and the construction industry is no exception. The lockdown for the COVID-19 pandemic caused business disruptions all over the world, primarily in the construction asset procurement and facility management sectors (Ogunnusi et al., 2020). As these serious and unexpected situations may recur in the future, it is important to know how they can affect sustainable facility management. For this purpose, it is necessary to understand the scientific contributions to sustainability and risk factors in facility management projects during the COVID-19 pandemic.

Therefore, the objective of the article is to investigate the contributions to benchmarking facility management to minimise the risks of the spread of the Covid-19 pandemic, highlighting its effects on sustainability. The study relied on expanding knowledge from previous studies by adopting bibliometric analysis of Scopus research data during the period of the coronavirus pandemic.

This article has five sections. A brief introduction is followed by a literature review on bibliometric research, then the research methodology is described, and the results are presented and discussed, describing the evolution of the field and the trends of the effect of COVID-19 risks in sustainable facility management. The last section offers conclusions, the study limitations and proposals for further research.

1. Literature review on bibliometric research regarding COVID-19

Despite the review articles not introducing new models or methodologies, these make a significant contribution by providing a brief, up-to-date overview of the field's evolution (Amin et al., 2019).

The bibliometric approach is useful for developing a summary of a research field because it identifies the most important trends in the field by analysing a variety of bibliometric indicators, including the number of publications and citations, the most influential countries, the most relevant authors, the most prominent institutions supporting research, and the

citations of papers in major articles (Martinez-López et al., 2020). Corsi et al. (2020) suggested that bibliometrics are a collection of methods to study or measure texts and information about all types of written communication, their authors, and publishing styles. Bibliometric is an open-source tool for quantitative research in scientific measurements and bibliometric developed by Massimo Aria and Corrado Cuccurullo. Because of open software, it is also easy to get help from the user community, which mainly consists of prominent statisticians. Therefore, bibliometric is flexible, quickly upgraded, and combined with other R statistical packages.

After the pandemic, several studies have been developed to ascertain the impact of COVID-19 on the development of many scientific fields, including facilities management benchmarking and risk management. Zhang et al. (2019) used a bibliometric-qualitative analysis to investigate 724 academic journal papers on FM issued between 1995 and 2018. Some of the latest advancements and emergent trends were identified based on knowledge maps in FM, including changing circumstances, enhancing information technology, all-around facility manager, strategic performance management, sustainable FM, and innovative FM practice.

Verma & Gustafsson (2020) analysed COVID-19 in the business management domain using Biblioshiny software and identified four main research themes: COVID-19 and business, COVID-19 and technology, COVID-19 and supply chain management, and COVID-19 and the service industry. Supply Chain Management and COVID-19 were also the focus of the research of the bibliometric analysis developed by Sombultawee et al. (2022). They found 257 papers published in 2020 and 2021 and identified four thematic clusters comprised of the impact of the COVID-19 pandemic on supply chains, the improvement of supply chain resilience for viability, technology and innovation for supply chain sustainability, and supply chain risk management in response to COVID-19. Within Cluster 4, one of the studied aspects was supply chain sustainability, i.e., the impacts caused by the COVID-19 pandemic as possible proposals to deal with COVID-19 disruptions.

Wang & Huang (2021) explored the publications in the Web of Science database related to the COVID-19 impact on sustainability by using bibliometrics techniques and the meta-analysis approach.

The results show that the research scope is extensive, covering many subjects but not in-depth. In addition, they show that the COVID-19 pandemic has negatively affected the 17 Sustainable Development Goals (SDG), whereas the pandemic may also bring opportunities to develop actions on 14 out of 17 SDGs.

Nobanee et al. (2021) used a bibliometric method to collect literature on sustainability and risk factors and analyse the relevant literature. This bibliometric analysis has been developed to understand further the importance of sustainability for individuals, businesses, and the economy. Moreover, risk-related factors were examined to prevent a negative impact. The researchers applied the following keywords: sustainability practices, risk assessment, sustainable development, and environmental impacts. The researchers used the VOSviewer software to analyse and identify citations relevant to topics critical to sustainability and risk contexts from 1990 to 2020. The results showed 1 233 Scopus documents on sustainability and risk management practices during the analysis. On the other hand, the researchers highlighted six main clusters relating to ethical responsibilities and sustainability development, blockchain technology and risk reduction, social and supply chain sustainability, environmental impacts, safety engineering, risk identification, and optimisation of sustainability practices. The researchers concluded in their study that sustainability practices represent a high-quality performance in the work environment, while risks remain a challenge.

Appiah et al. (2022) developed a scientific map and conducted an in-depth analysis of the knowledge supplied by management professionals examining the influence of COVID-19 on business performance. Researchers looked for "COVID-19" and "Coronavirus" in combination with other keywords ("value", "performance", or "profitability") in the Scopus database. They identified three main research clusters: foundational discussions and risk assessment, crisis and strategic management and performance outcomes and strategies. They identified some research gaps that could point to future lines of research. One of them is the lack of attention to the supply chain's reactions under different pandemic plans, as different elements of the supply chain can influence the management during such a crisis as COVID-19 (Kryeziu et al., 2022).

Other bibliometric research on COVID-19 showed the importance of the sustainability concept for the post-COVID-19 period, as in the research of the management strategies and policies in hospitality and tourism (Khan, Nasir, & Saleem, 2021) and the human mobility behaviour (Benita, 2021). The

authors pointed out the importance of the operations and maintenance of vehicles and facilities as one of the sustainable actions to be included in post-COVID management.

2. Methodology

The methodology of this research is a bibliometric analysis. It was divided into two phases: first, a bibliometric performance analysis and second, the development of a visual mapping of the references within the facility management, risk management, and sustainability research field. Bibliometric analysis is considered one of the best techniques for mapping and analysing study production and the success of academics, authors, educational institutions, countries, and even journals in a specific subject area (Olawumi & Chan, 2018).

Many databases may map bibliographic data, including Dimensions Database, Google Scholar, Web of Science, and Scopus. The Scopus Database was utilised to analyse the influence of COVID-19 hazards on sustainable facility management. The authors conducted a bibliometric examination of the Scopus database journals, focusing on the Science Citation Index Expanded and the Social Sciences Citation Index. Scopus was chosen as the search database because it covers a larger number of publications and journals than other databases. In addition, Scopus contains a wealth of information, including the year of publication, authors, authors' affiliations, title, abstract, source journal, subject categories, and references.

The period for the bibliometric analysis was between 2019 and 2021, and the keywords used were "facility management", "risk management", "Covid-19", and "sustainability". Only articles published in English were selected. The researchers have exported the bibliographic details from the Scopus database in Bibliography Tex (.bib). Then, the R Studio was installed and loaded with the bibliometric R kit (version 3.0.3 published 28-Sep-2020). The R-package bibliometric (https:/www.bibliometrix.org/) was used for overall analysis in scientometrics and bibliometrics. It is developed in R, uses efficient mathematical algorithms, and access to high-quality computational procedures, and is an optimised visual analytics software (Aria & Cuccurullo, 2017).

A total of 208 documents were selected and included in the second study phase. The development of graphical mapping of bibliometric material was performed with the VOSviewer software (version 1.6.15, Nees Jan van Eck and Ludo Waltman, Melbourne, Leiden, The Netherlands). The researchers have used the VOSviewer software to visualise and map the co-occurrences for keywords, countries for co-authorships, most relevant affiliation, three fields plot, and factorial map in the exported data.

3. Results and discussion

3.1. Primary information

The primary information extracted from Scopus is shown in Table 1. The exported data consist of 208 documents from 2019 to 2021 (n=28 documents in 2020, n= 174 documents in 2021, and n= 5 documents in 2022) published in 124 different sources. The collected papers have 0.135 average years from publication and 5.058 average citations per article. All the sources have 32,552 references. The main information extracted from 208 sources can be found in Table 1.

3.2. Keyword analysis

The Scopus database was used to export bibliographic data for bibliometric analyses and mapping with the VOSviewer software. Co-occurrence analysis was used for all keywords to indicate the full strength between keywords and their occurrences. The clusters' volume indicates the strength and importance of words. In addition, the colours show the significance of clusters, and the curved lines indicate the links between words. A total of 3 302 text-data terms appeared, and 73 met the threshold of 5.

Fig. 1 illustrates the co-occurrence map of keywords. The map consists of six clusters; the strongest cluster refers to the COVID-19 keyword, which occurred 88 times and related to almost all other keywords, indicating the high impact and strong effect. The different keywords for each cluster were ranked in order of strength, i.e., sustainability, supply chain, decision-making and facility management.

Cluster 1: "The effect of COVID-19 risks on human health"

Table 2 presents keywords that belong to Cluster 1, including the number of occurrences of these keywords and the number of links they have. Cluster 1, "The effect of COVID-19 risks on human health", has

Tab. 1. General information exported from the Scopus database

DESCRIPTION	RESULTS
Main information about the data	
Time span	2019:2022
Sources (Journals, Books, etc.)	124
Documents	208
Average years from publication	0.135
Average citations per Document	5.058
Average citations per year per Document	
References	32552
Document Types	
Article	163
Book	5
Conference paper	2
Note	1
Review	37
Document contents	
Keywords Plus (ID)	1417
Author's Keywords (DE)	915
Authors	
Authors	923
Author Appearances	978
Authors of single-authored Documents	16
Authors of multi-authored Documents	907
Authors collaboration	
Single-authored documents	18
Documents per Author	0.225
Authors per Document	4.44
Co-Authors per Document	4.7
Collaboration Index	4.77

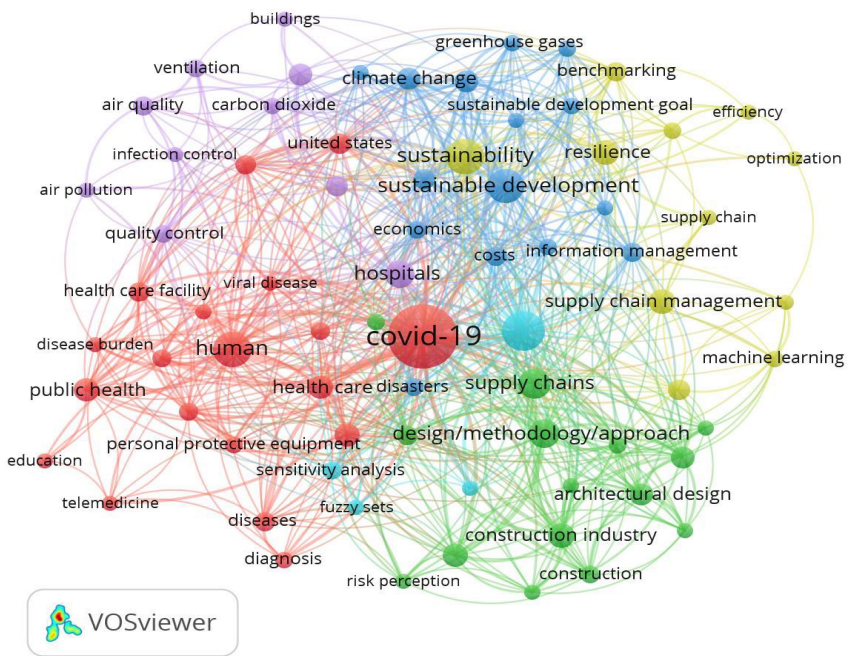

Fig. 1. Co-occurrence map for all keywords

Tab. 2. Keywords in Cluster 1 "The effect of COVID-19 risks on human health"

Keywords (Cluster 1): The effect of COVID-19 risks on human health	Links	Total Links Strength	Occurrences
Covid-19	62	199	88
Human	41	101	28
Health care	25	37	12
Public health	22	43	12
Risk assessment	27	42	12
Diseases	19	29	8
Health care facility	21	35	8
Waste management	24	41	8
Health risks	24	35	7
Epidemic	19	31	7
Developing countries	19	23	7
Personal protective equipment	18	25	6
Diagnosis	11	16	6
Viral disease	21	34	5
Water management	17	23	5
Disease burden	13	19	5
Telemedicine	10	13	5
Education	5	7	5

18 items. Keywords, such as health care and health risks, are the top themes in this research field.

COVID-19 is mostly spread through individual interaction, and the most successful tactics used by most authorities in afflicted nations to limit the disease have been social separation and lockdown (Pullano et al., 2020; Singh et al., 2020). The lockdown due to COVID-19 had both direct and indirect consequences: on the one hand, it had a significant economic, social, and cultural impact (Sarkar, Das, & Mukhopadhyay, 2021), while on the other, an improvement in air quality was observed in cities where these restrictions were implemented to contain the COVID-19 epidemic and achieve good human health (Baldasano, 2020).

For this reason, efforts may and should be taken to reduce the psychological and mental impacts of the COVID-19 epidemic. First, while it may appear appealing to re-deploy mental health professionals to other healthcare areas, this should be avoided. Such a change would almost surely reduce overall results and put those with mental illnesses at a disproportionate risk of physical and mental health deterioration. This group, if anything, currently needs greater attention (Cullen et al., 2020).

Second, we advocate for the provision of targeted psychological interventions in communities affected by COVID-19 with a focus on people at high risk of psychological morbidity, increased awareness, and diagnosis of mental disorders (particularly in primary care and emergency departments), and improved access to psychological interventions (particularly those delivered online and via smartphone technologies). These measures can help reduce or prevent future psychiatric visits (Cullen et al., 2020).

Cluster 2: "Supply chain in construction project and industry"

Table 3 presents the keywords that belong to Cluster 2, including the number of occurrences of these keywords and the number of links they have. Cluster 2, "Supply chain in construction project and industry", has 15 items. Keywords such as "project management" and "construction design methods" are the top themes in this research field.

Due to the obvious challenges of managing connections of a wide range of different businesses, supplying components, elements, the number of services, and interpersonal conflicts, supply chain implementation has obtained obstacles in the construction sector (Öztürk & Yildizbaşi, 2020; Ershadi et al., 2021).

Stone & Rahimifard (2018) stated that current manufacturing research in the supply chain, while useful, could indeed be readily applicable to a constrained context.

Tab. 3. Keywords in Cluster 2 "Supply chain in construction projects and industry"

Keywords (Cluster 2): Supply chain in construction projects and industry	Links	Total Links Strength	Occurrences
Supply chains	32	53	20
Design/methodology/approach	32	68	18
Construction industry	22	52	13
Surveys	21	39	12
Project management	23	44	11
Architectural design	22	36	10
Human resource management	27	40	8
Environment structured	18	27	7
Structured semi	18	23	6
Semi-structured interviews	19	31	6
Accident prevention	16	18	5
Automation	8	8	5
Building information modelling	15	22	5
Construction projects	16	26	5
Risk perception	14	18	5

Although an efficient supply chain is essential for lowering supply chain management construction costs, Prajogo, Mena & Nair (2017) observed that relatively little research has defined what the term "supply chain" implies in the context of the construction process. As a result, we chose to begin by defining the supply chain.

The construction industry has seen the launch of many Supply Chain Management (SCM) initiatives aimed at improving internal and external efficiency, reducing waste, and adding value across the entire supply chain, as well as attempting to eliminate adversarial inter-organisational purchaser-supplier relationships and fragmented business processes (Broft, Badi & Pryke, 2016).

Scholars have widely recognised the importance of SCM's contribution to improving company performance at various levels (strategic, tactical, and operational), thus shifting the focus from the internal structure to the external inter-organisational processes and relations, thereby enhancing strong feedback linkages and collective learning. However, SCM adoption in the construction sector has been fragmented and ineffective thus far (Neutzling et al., 2018).

SCM must be adequately defined, planned, structured, and carried out. As a result, the adopting organisations (primarily the general contractor and its subcontractors) must deal with managerial, organisational, relational, and technological issues that must be managed appropriately to effectively apply SCM principles, models, and techniques and overcome barriers to construction SCM application (Broft, Badi & Pryke, 2016).

Cluster 3: "Disaster risk management in a changing climate"

Table 4 presents the keywords that belong to Cluster 3, including the number of occurrences of these keywords and the number of links they have. Cluster 3, "Disaster risk management in a changing climate", has 15 items. Keywords such as "sustainable development", "environmental climate change", "disaster", and "risk management" are the top themes in this research field.

Climate change mitigation, e.g., pollution reduction, has long been a component of sustainable developmental projects. Climatic change adaptation covers a set of actions aimed at mitigating risks and extracting advantages from climate extremes or changes. These actions are included in the concept of disaster risk reduction (Kelman, 2017; Szpilko & Ejdys, 2022).

There are two main components of Disaster Risk Management (DRM): Disaster Risk Reduction (DRR) and Disaster Management (DM). DRR is the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including reduced exposure to hazards, lessened vulnerability of people and property, wise land and environment management,

Tab. 4. Keywords in Cluster 3 "Disaster risk management in a changing climate"

Keywords (Cluster 3): Disaster Risk Management in a Changing Climate	Links	Total Links Strength	Occurrences
Sustainable development	40	86	25
Environmental impact	29	50	11
Climate change	28	43	11
Life cycle	29	50	9
Costs	25	34	8
Information management	21	25	8
Economics	24	38	7
Disasters	16	18	7
Investments	24	28	6
Greenhouse gases	20	28	6
Sustainable development goal	19	23	6
Planning	15	23	6
Risk management	22	24	5
Economic and social effects	20	26	5
Environment	18	20	5

and improved preparedness for adverse events. DM describes the development and application of policies, strategies, and practices that minimise vulnerabilities and disaster risks throughout a society, to avoid (prevent) or limit (mitigate and adapt to) the adverse impacts of hazards within the broad context of sustainable development (Begum et al., 2014).

Flood, weather, and drought risk reduction implemented for climate change adaptation is the same as disaster risk reduction implemented in general. Work to modify crops and extend growing seasons in response to climate change is strongly connected to prior efforts to use local knowledge to improve food security, especially for disaster risk reduction. As a result, to achieve sustainable development, a systematic relationship between Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) is required (Birkmann & von Teichman, 2010).

Climate change has two actions: adaptation and mitigation, which are still divided despite having much in common. Climate change could be usefully placed within other sustainable development activities to avoid separating it from other activities and to accept all the overlaps and links because climate change adaptation is no different from disaster risk reduction, so it fits within that topic, which fits within sustainable development (Kelman, 2017).

Cluster 4: "Sustainable supply chain benchmarking"

Table 5 presents the keywords that belong to Cluster 4, including the number of occurrences of these keywords and the number of links they have. Cluster 4, "Sustainable supply chain benchmarking", has 11 items. Keywords such as "sustainability" and "benchmarking" are the top themes in this research field.

Due to globalisation, market demand unpredictability, and current economic competitiveness, business organisations face a major challenge to their present supply chain. Simply focusing on internal efficiency and supply chain operations will not be enough for any company to acquire a competitive advantage in the market. To meet these mounting issues, sustainability performance has gained importance in recent years. Integrating sustainability principles into essential supply chain business processes allows organisations to establish a "competitive position" in the market in this modern era of a globally challenging environment.

Sustainable Supply Chain Management (SSCM) is viewed as the beginning of a new integrated environmental performance, social performance, and economic contribution — or what has been referred to as a combination of three pillars of sustainable development. Implementing SSCM techniques leads to enhanced material and energy efficiency, as well as

Tab. 5. Keywords in Cluster 4 "Sustainable supply chain benchmarking"

Keywords (Cluster 4): Sustainable supply chain benchmarking	Links	Total Links Strength	Occurrences
Sustainability	35	70	27
Supply chain management	15	20	14
Resilience	18	27	13
Artificial intelligence	14	17	9
Benchmarking	24	30	8
Data envelopment analysis	11	15	6
Machine learning	10	13	6
Forecasting	10	13	5
Efficiency	7	9	5
Supply chain	8	13	5
Optimisation	4	5	5

innovation, which improves an organisation's economic performance and establishes a brand corporate reputation in the market (Ansari & Kant, 2017).

The benchmarking concept, which comes from the English word benchmark ("milestone", "landmark"), is broadly practised in the US but has known international expansion in recent decades. The method consists of a systematic and permanent process of measuring and comparing the work processes of an organisation with those of another one to increase performance. It necessarily involves measurement and can be a learning method in an organisation about areas and the way that activity could be improved (Smallwood, 2019).

External standards that measure the quality of all aspects must and can help identify opportunities to improve SSCM activity and to identify "best practices" in their field of activity; however, in addition to standards-based measurements, there is a need for a desire and willingness to learn from the "good" or "bad" practices. To do this, strong trust-based communication with all local and central superordinate organisations is required to overcome internal reluctance to implement the necessary change. What and how other comparable companies have accomplished can be taken and incorporated into their organisational procedures.

Last but not least, any optimisation process carried out in any firm or company that resulted in redefining roles and activities following a new instructional design must support the valuable traditional aspects in the functioning of SSCM organisations and facilitate the creation of the necessary correlations with the innovative elements so benchmarking becomes a part of a total quality management approach to facility management (standards, indicators, rules, etc.).

Cluster 5: "Facility management and quality control"

Table 6 presents the keywords that belong to Cluster 5, including the number of occurrences of these keywords and the number of links they have. Cluster 5, "Facility management and quality control", has 11 items. Keywords such as "energy utilisation", "efficiency", and "quality control" are the top themes in this research field.

Performance measurements can be analysed statistically, as in manufacturing, to assess whether the processes that a facility manager is executing to offer a service are under control. The advantage of Statistical Quality Control (SQC) is that it allows the facility manager to make sense of the outcomes produced in nearly any repeatable operation for which they are accountable (Montgomery, 2020).

The advantages of using SQC as a measuring tool are that it allows the FM to determine if a given process is under control and working consistently. An essential aspect of this is the capacity to explain to service users why action is not required every time a result deviates from the expectation. It enables the personnel to see how they are performing and to participate in the measurement and serves as a foundation for thinking about how to enhance the process and measuring how effectively a change is functioning (Dillon, 2021).

Sustainable Facilities Management (SFM) allows businesses to assess the quality of their resources and environmental management at their facilities. Furthermore, to maintain the operation of the built

Tab. 6. Keywords in Cluster 5 "Facility management and quality control"

Keywords (Cluster 5): Facility management and quality control	Links	Total Links Strength	Occurrences
Hospitals	30	46	16
Energy utilisation	13	19	10
Energy efficiency	8	14	9
Air quality	12	17	8
Quality control	22	25	7
Ventilation	8	11	7
Carbon dioxide	19	23	6
Air pollution	7	10	5
Buildings	6	8	5
Infection control	9	11	5
Optimisation	4	5	5

environment, SFM necessitates the integration of many disciplines, including Mechanical, Electrical, Plumbing, and Fire Protection (MEPFP) (Ruan, Xie, & Jiang, 2017). The management and control of MEPFP systems in a facility are very important in building the operation and maintenance of SFM, especially in complex projects, such as hospitals, science labs, and technology parks, where the total investment of MEPFP systems on average can even reach 50 % of the total investment of such a project. SFM plays an important role in the development, maintenance, and management of these complex infrastructures, as it integrates people, location, and business to maximise the economic, environmental, and social advantages of sustainability.

Cluster 6: "Sensitivity analysis and decision making"

Table 7 presents the keywords that belong to Custer 6, including the number of occurrences of these keywords and the number of links they have. Cluster 6, "Sensitivity analysis and decision making", has 3 items. Keywords such as "sensitivity analysis" and "decision-making" are the top themes in this research field.

Writers commonly fail to examine solutions using numerous Master Data Management (MDM) methodologies and perform sensitivity analysis (Payam & Fathipour, 2015). According to the research, selecting the ideal MDM technique is a very complicated problem that, if not preceded by a sensitivity analysis of the solution, might result in a mistake decision if an MDM method that produces inconsistent results is selected (Pamučar, Božanić & Ranđelović, 2017). Therefore, models for evaluating the outcome consistency of multicriteria decision-making (MCDM) procedures are required. As a result, the model for sensitivity analysis (assessment of outcome consistency) of MCDM approaches must be defined. The prime objective of the sensitivity analysis of the technique proposed in this research is to choose such a technique that keeps the majority of priority areas during the modification of criteria weights and that wants to keep the rankings of alternative solutions in case of scales to measure change and shift in the way the requirements is constructed (Mukhametzyanov & Pamucar, 2018).

In MCDM, it is possible to see examples of examination of ranking outcomes acquired using various methodologies. It should be mentioned that the outcomes of this type of study are dependent on the observed technique choice and the features of the issues to which those methods are applied (Mukhametzyanov & Pamucar, 2018). As a result, various authors have reached various conclusions. In works in which structural rigidity and stability analysis of obtained solution is performed in MDM, analysis is frequently based on appropriate sensitivity analysis of results to changes in certain variables in

Tab. 7. Keywords in Cluster 6 "Sensitivity analysis and decision-making"

Keywords (Cluster 6): Sensitivity analysis and decision-making	Links	Total Links Strength	Occurrences
Decision-making	55	109	33
Sensitivity analysis	16	21	7
Multi-criteria decision making	9	13	5

the decision-making model, in addition to comparing with the result provided through other strategies and processes (Pamučar, Božanić & Randelović, 2017).

3.3. Affiliation

In Fig. 2, the most relevant institutions that support this research topic and the number of articles for each institution are represented. Cebu Technological University had the highest number of publications (eight documents) during the study period. There are 14 different universities publishing the topics of the research (84 % of all documents). The minimum number of publications was three documents for eight various institutions.

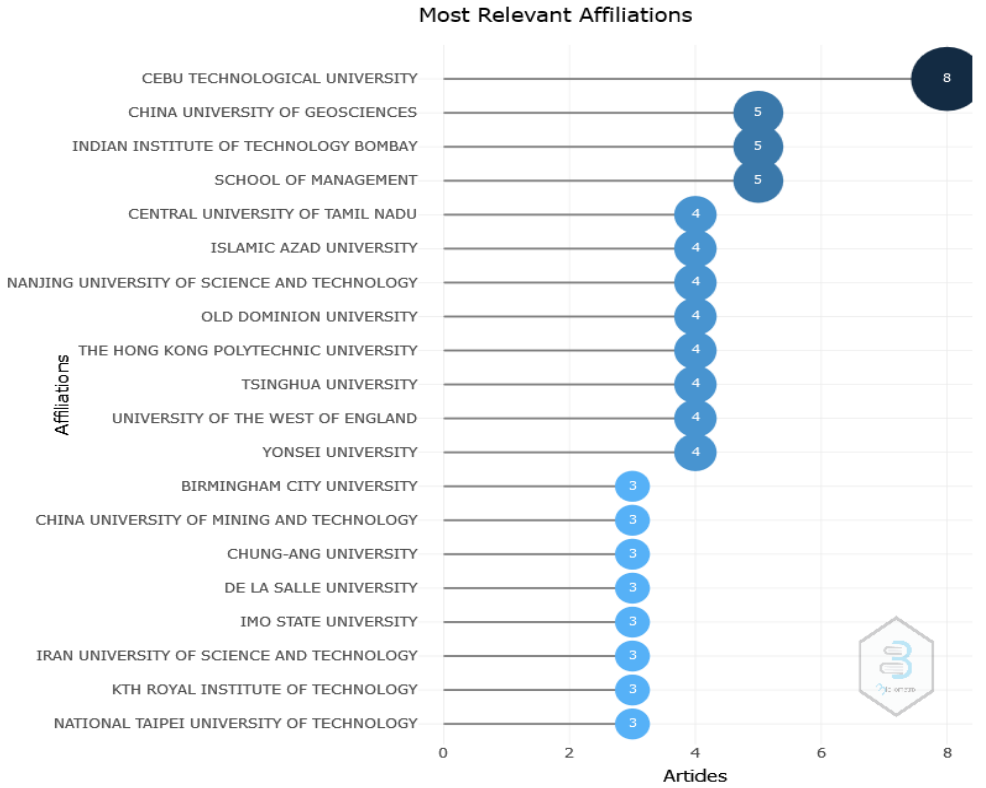

Fig. 2. Most relevant affiliations

3.4. Three-fields plot

The analysis established which research keywords had been used most frequently (right) by different affiliations (middle) and countries (left). The study of the top keywords, affiliations, and countries indicated that there were five keywords (decision-making, sustainable development, COVID-19, human health and risk assessment) and four countries (USA, China, India, and Iran) supported by five institutions (Indian Institute of Technology Bombay, Kth Royal Institute Of Technology, Tsinghua University, Cebu Technological University, Cebu Technological University, and China University of Geosciences) as shown in the Sankey diagram, given in Fig. 3 (Kumar & Goel, 2021).

3.5. Country collaboration map

The country's collaboration map is used to measure the international collaboration intensity of a country. Australia and Canada are the countries with the strongest contribution, and the UK is symbolised by the dark blue colour. According to Fig. 4, Bangladesh is the country where several documents were written by five co-authors, followed by Brazil with one collaboration (El Baz & Iddik, 2021).

3.6. Factorial map of the documents

For each cluster of the conceptual structure map, the factorial map of the documents with the most contributions identifies the group of papers using mainly specific keywords. As this analysis is based on the use of a keywords co-occurrence network, the

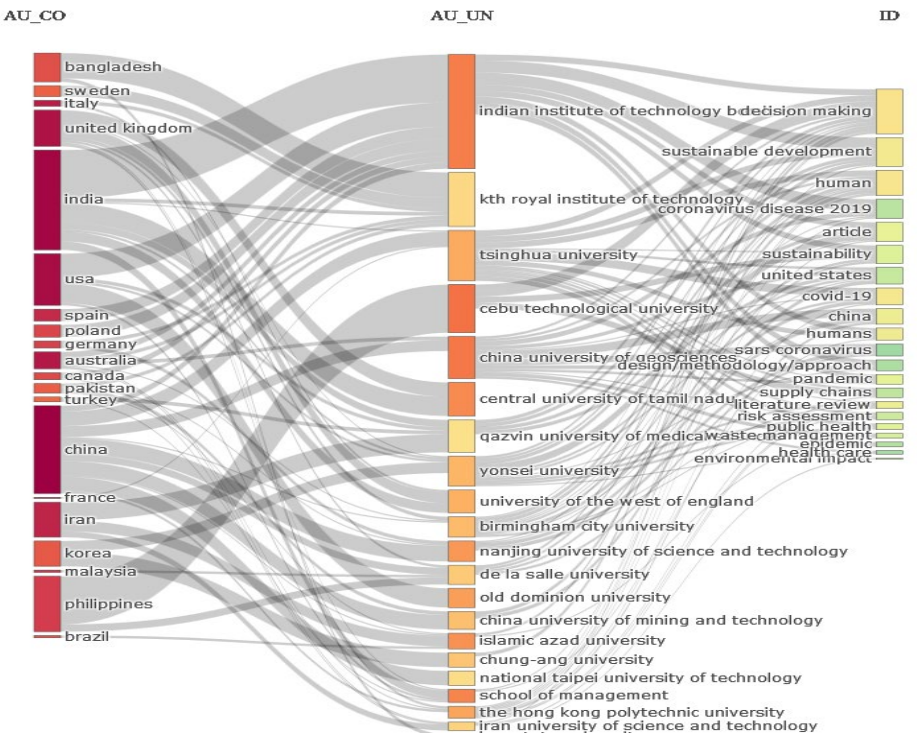

Fig. 3. Three-Fields Plot keyword (right), affiliations (Middle), and countries (left) (Sankey diagram)

Tab. 8. Countries' collaboration worldwide

From	To	Frequency	From	To	Frequency	From	To	Frequency
AUSTRALIA	BANGLADESH	3	AUSTRALIA	NORWAY	1	BRAZIL	PAKISTAN	1
AUSTRALIA	CANADA	3	AUSTRALIA	PAKISTAN	1	CANADA	COLOMBIA	1
AUSTRALIA	DENMARK	1	AUSTRALIA	POLAND	1	CANADA	FINLAND	1
AUSTRALIA	FINLAND	1	AUSTRALIA	QATAR	1	CANADA	GREECE	1
AUSTRALIA	FRANCE	1	AUSTRALIA	SINGAPORE	2	CANADA	INDONESIA	1
AUSTRALIA	GERMANY	2	AUSTRALIA	SOUTH AFRICA	1	CANADA	IRELAND	2
AUSTRALIA	GREECE	1	AUSTRALIA	SPAIN	2	CANADA	JAPAN	1
AUSTRALIA	HONG KONG	2	AUSTRALIA	SWEDEN	2	CANADA	MEXICO	1
AUSTRALIA	IRAN	1	AUSTRALIA	SWITZERLAND	2	CANADA	NETHERLANDS	2
AUSTRALIA	IRAQ	1	AUSTRALIA	YEMEN	1	CANADA	NEW ZEALAND	2
AUSTRALIA	IRELAND	2	AUSTRIA	HUNGARY	1	CANADA	NIGERIA	1
AUSTRALIA	ITALY	1	AUSTRIA	TUNISIA	1	CANADA	NORWAY	1
AUSTRALIA	MALAYSIA	2	BANGLADESH	JAPAN	1	CANADA	SINGAPORE	1
AUSTRALIA	MEXICO	1	BANGLADESH	NETHERLANDS	1	CANADA	SOUTH AFRICA	1
AUSTRALIA	NETHERLANDS	3	BANGLADESH	NIGERIA	1	CANADA	SWEDEN	2
AUSTRALIA	NEW ZEALAND	1	BANGLADESH	PAKISTAN	1	CANADA	SWITZERLAND	1
AUSTRALIA	NIGERIA	1	BANGLADESH	SWEDEN	1			

papers mentioned in each cluster identified the connections among the keywords (Lamboglia et al., 2020) (e.g., one paper could use two or more of those keywords). Fig. 5 shows one cluster (red colour) consisting of various elements of the documents of the highest contributions. The similarity is measured by the distance between any row points or column points (Syed & Bawazir, 2021).

Fig. 5 highlights the most contributing documents using a factorial map. Since Bibliometrix – R tool allows factorial analysis to determine the conceptual structure of the bibliometric data; it is an interesting black-box-based alternative to view the cluster components based on closeness calculated using the Correspondence Analysis (CA) multivariate statistical technique (Ghosh & Prasad, 2021). The dimensions or factors considered are keywords (no documents per author) and Total Citations (TC).

As observed in the figure, the documents appeared in one cluster across two dimensions

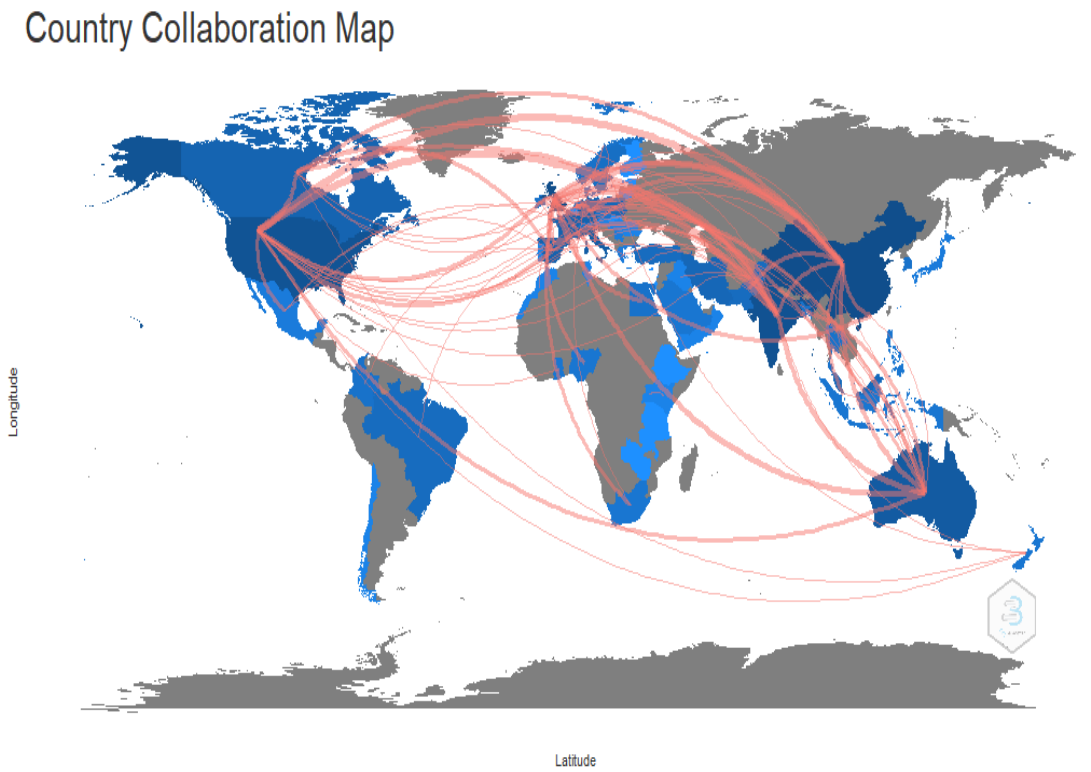

Fig. 4. Country collaboration map on keywords literature around the world

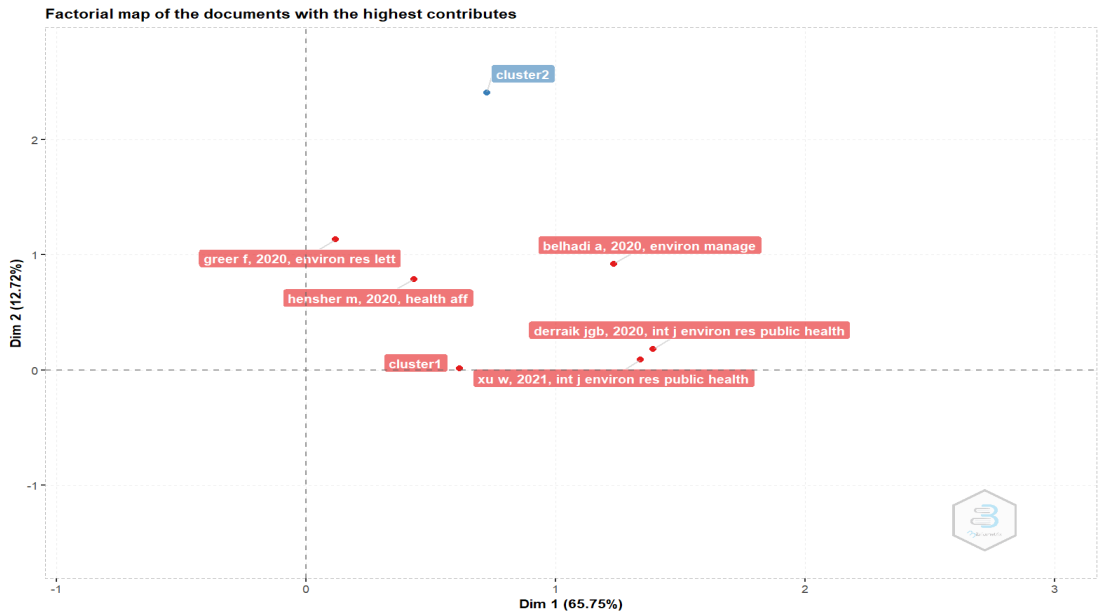

Fig. 5. Factorial map of the documents with the highest contributions

(DIM1=key words; DIM2=total citations). Five documents from Cluster 1 are ranked with the highest contributions as they fall under the positive quadrants of both dimensions. Cluster 1 explains the effect of COVID-19 risks on human health. For example, Belhadi et al. (2020), in the article "Infectious waste management strategy during the COVID-19 pandemic in Africa", studied an integrated decision-making framework for selecting sustainable technologies in environmental management.

In addition, as shown in the figure, Xu et al. (2021) presented a study on the influence of COVID-19 on community disaster resilience.

Conclusions

After analysing 208 articles and 73 keywords, the six identified clusters (the effect of Covid-19 risks on human health, supply chain in construction projects and industry, disaster risk management in a changing climate, sustainable supply chain benchmarking, facility management and quality control and finally, and sensitivity analysis and decision-making) revealed that the COVID-19 pandemic has a continuous and direct impact on sustainable development goals, specifically human health, and care in various work communities, such as construction projects and the industry, where risk management must be applied strongly to minimise the dangers of both the individual and the work environment. This can be accomplished by implementing supply chain management to improve internal and external efficiency, reduce waste, and improve productivity.

Sustainable Supply Chain Management (SSCM) is viewed as a promising integrated sustainable development framework, and benchmarking can be a learning method for organisations. External standards and what and how other comparable companies have performed can be incorporated into their organisational procedures.

In addition, risk management is an important field in facility management because it serves the built environment. Thus, research in the field of risk management and prevention of COVID-19 in projects and facilities needs an integrated approach. Research in this specific risk management area should give more weight, at least in some areas, to the perspectives of facility managers and other people responsible for the built environment. The benefit of statistical quality control is that it provides the facility managers with the ability to make some sense of the results being achieved in virtually any repetitive procedure for which they are responsible, so the benchmarking becomes a part of the total quality management for facility management to improve and increase the efficiency of decision-making.

Among the limitations of the study, two aspects can be pointed out. The first is that the bibliometric analysis did not consider publications from other databases with a lower impact, such as Google Scholar, EBSCO and PubMed. Secondly, the clustering of the analysis may lead to concepts that are spread across both clusters, and in the future, they may become central to research in sustainable facilities management in the post-COVID period.

The effects of COVID-19 seem to have been largely overcome or learned to cope with, but political-economic instability continues to pose new problems that call for future research on sustainable facility management, new supply chain challenges in construction projects and ways to improve risk management in uncertain scenarios.

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IT reliability as a source of sustainability for organisations operating during the COVID-19 pandemic

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ABSTRACT
The article aims to show that reliable IT support was crucial for the survival and sustainability of organisations during the COVID-19 pandemic. The article considers the negative effect of the crisis caused by the COVID-19 pandemic on the organisational sustainability of an organisation (i.e., organisational performance through employee job performance). It explores the role of IT reliability in mitigating such a negative effect. To verify the hypotheses, the empirical studies were performed during the COVID-19 crisis with 1160 organisations operating in Poland, Italy and the USA. The data were analysed using multiple linear regression models with mediators and moderators. The results confirmed that due to the ability to limit the severity of a crisis-induced negative effect on employee job performance (influencing organisational performance), IT reliability could be considered a mitigator for the negative effect of the COVID-19 crisis on the sustainability of organisations. The results indicate that IT reliability should be fostered among organisations operating during the COVID-19 pandemic to maintain sustainability.

KEY WORDS
IT reliability, organisational performance, job performance, organisational sustainability, COVID-19

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Introduction

The COVID-19 pandemic, which started in 2019, caused unprecedented international restrictions and severe human, social, and economic disruptions worldwide due to social distancing or stay-at-home protocols (Gossling et al., 2021; Tan Vo-Thanh et al., 2021). The pandemic impacted the world with sharp shocks to economies and societies worldwide (MacIntyre, 2020; Shigemura et al., 2020). Hamouche (2020) stated that "this situation can have a negative impact on business sustainability and individual employment". Researchers almost instantly began

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looking for helpful ways for organisations to maintain sustainability and survive the crisis. The notion of IT support for organisations operating in such an extremely turbulent environment influenced by the COVID-19 pandemic received some attention in the literature (He et al., 2021; Tahar et al., 2021). One of the most heavily discussed topics is IT-related: the business alignment, which must be maintained to gain an advantage from IT support in such a situation (Tahar et al., 2021) as remote work and remote education became essential and were required by law in many countries in the attempt to help societies to slow down the COVID-19 spread (He et al., 2021; Loh & Fishbane, 2020; Young, 2020). Hence, IT support became essential in maintaining the sustainability of organisations aiming to survive and sometimes even thrive in the COVID-19 pandemic. Colbert and Kurucz (2007) proposed the colloquial definition of sustainability as "keep the business going", which not only refers to the economic but also social and environmental perspectives (Wales, 2013). Clearly, achieving that objective without the support of IT during COVID-19 was almost impossible. To achieve sustainability, organisations were forced to speed up the development and implementation of new or changed IT to align it with the organisation's changed needs (He et al., 2021; Sein, 2021). There is a rising number of empirical research papers connected to this topic, aiming to explain the implications of COVID-19 for the design, implementation, and use of IT for sustaining organisations' operations (Sein, 2021; Budd et al., 2020). Moreover, He and Harris (2020) suggested that COVID-19 could also present an "opportunity for organisations to shift towards more authentic and genuine corporate social responsibility (CSR)"; however, such an opportunity cannot be properly exploited without IT support. Hence, its role is crucial not only for obtaining and maintaining but also for boosting the sustainability of contemporary organisations.

However, even more importantly, from the point of view of organisational sustainability, organisations were forced to focus their efforts on supporting the reliability of used IT, as without it, they would have been left without any possibility of performing tasks and surviving. A negative influence of the COVID-19 pandemic on job performance and organisational performance is apparent, and any measures allowing to mitigate it were considered key for such survival. Unfortunately, the literature coverage of the topic is still very limited, which constitutes a research gap. Filling such a research gap will not only contribute to the development of the field of IT use in organisations operating under critical conditions but also provide some practical implications for organisations striving to maintain their sustainable development.

Therefore, the article aims to verify whether IT reliability (considered, among others, as a notion reflecting the IT-business alignment within the organisation) mitigated the negative effect of the COVID-19 pandemic on organisational performance (through employee job performance) and whether the strength of such mitigation increases with the deepening of the crisis. In pursuit of the aim, a literature review was undertaken to support the proposed hypotheses, and empirical research was performed with 1200 organisations from various countries influenced by the COVID-19 pandemic to verify those hypotheses.

1. Literature review

The connection between organisational sustainability and organisational performance is not limited to economic results but also the effects on the environment, society and future generations (Rai et al., 2021). Therefore, organisations must manage various social and environmental issues to ensure the next generations' future while securing the organisation's survival, which is connected to its performance (Mani et al., 2016). As well described in the literature, social and environmental aspects are deeply rooted in the economic aspect of organisational sustainability (Manca, 2015). Some scholars disagree with this attitude towards organisational sustainability, considering it a complex issue that "requires a holistic perspective to balance the sustainability, i.e., the economic, environmental, social and time dimensions" (Lozano & Barreiro-Gen, 2021).

However, it seems particularly adequate for an organisation during the COVID-19 pandemic (Lozano & Garcia, 2020; Lozano & Barreiro-Gen, 2021). It is already well-established that COVID-19 caused immense negative social, human, and economic effects worldwide (Gossling et al., 2021; Hall et al., 2020; Tan Vo-Thanh et al., 2021). Barreiro-Gen and colleagues (2020) underlined that COVID-19 caused a shift in the sustainability priorities of organisations because it presented a significant threat to their survival. Such survival denoted in organisational performance is crucial for allowing an organisation to consider all other aspects of its sustainable operations (Gregurec et al., 2021). Moreover, in times

of such a crisis, the social responsibilities of organisations are primarily focused on the ability to create and maintain jobs, limit staff cuts and reduce the pace of economic slowdown. Hence, from the point of view of an organisation's sustainability, maintaining organisational performance was crucial. This point of view has been confirmed by various empirical research on organisational sustainability during COVID-19, usually measured using selected aspects of organisational performance elements found in the business scorecard approach (e.g., Park et al., 2021; Correia et al., 2021). The same approach is used in this article.

1.1. Job performance as a main determinant of organisational performance

It is well established that employee job performance, as the most important resource, is one of the key factors determining the organisational performance of contemporary organisations (Forooqui, 2014; Sonnentag & Frese, 2002). Hence, job performance should be referred to as the implementation of assigned tasks by an individual (Darvishmotevali & Ali, 2020). This statement is confirmed by various empirical research, including Brewer and Selden (2000), who stated that organisational performance is mostly determined by the structure of task/work and task motivation shaping employee individual performance. Sonnentag and Frese (2002, p. 4) underlined that "organisations need highly performing individuals in order to meet their goals (…), and finally to achieve competitive advantage".

While analysing the usually given main reason for such a clear relationship between job performance and organisational performance, one argument arises especially often. Many authors state that high performance among employees easily translates into their ability to boost the organisation and create the possibility to fulfil the strategic aims and, based on that, achieve higher performance and organisational sustainability (Lado & Wilson, 1994; Dessler, 2011; June & Mahmood, 2011).

Moreover, various empirical research efforts confirm the influence of typical job-related attitudes, such as job satisfaction, work motivation, or organisational commitment, on the organisation's performance (Kim, 2004; Koys, 2001; Jaramillo et al., 2005). Job-related attitudes directly influence job performance (e.g., Iqubal et al., 2013; Ali et al., 2018; Moonti et al., 2023), which also shows the mechanism of the relationship between job performance and organisational performance.

Such relationships became even more significant for organisations during the COVID-19 pandemic, which had direct negative effects on employees and their ability to perform everyday tasks. Tanveer et al. (2020) stated that during the COVID-19 pandemic, "the effectiveness and efficiency of the organisation depend on the joint efforts of all employees", and proper job performance should be considered the main determinant of the overall organisation's performance. Several researchers have already stated that during the crisis caused by the COVID-19 pandemic, organisations simply had to pay much more attention to employees as key resources (Mao et al., 2020; Tan Vo-Thanh et al., 2021). Such a need came directly from the resource conservation theory (Hobfoll, 1989), which underlines that employee stress can affect their job performance, and a crisis in an organisation, such as caused by COVID-19, is an immense stressor for employees due to the fear of changes in task fulfilment (to enable the continuity of operations) or downsizing (to diminish labour costs) (Baum et al., 2020; Tan Vo-Thanh et al., 2021). It connects with job insecurity and negatively affects employee job performance (Hamouche, 2020). Based on such arguments, several authors stated that the crisis caused by the COVID-19 pandemic leads to lower job performance (Hamouche, 2020; Tan Vo-Thanh et al., 2021, Gossling et al., 2021; Hall et al., 2020). Moreover, Darvishmotevali & Ali (2020) underlined that such a negative effect on employee job performance is caused by decreasing subjective wellbeing (in the case of job security and job conformity). Hence, it is not enough to establish that no downsizing would be performed to maintain a proper level of job performance. It is even more crucial to maintain work environment characteristics, which allow employees to perform their tasks (which became especially hard during the COVID-19 pandemic due to social distancing and stay-at-home regulations that forced employees to redesign their task implementation ways (Gossling et al., 2021)). Hence, it seems that such a crisis is negatively influencing organisational performance through employee job performance. Consequently, the following hypothesis was formulated:

H1. The crisis caused by the COVID-19 pandemic has a negative influence on organisational performance through employee job performance.

2. IT reliability among organisations during COVID-19

The reliability of IT in an organisation is "a measurable property of IT solutions, useful for their control and management, identifying their quality level and pointing out potential problems (Zahedi, 1987) and directly linked to the efficiency of IT components, especially those critical to its proper operations. It is also considered as a measure of IT solutions stability over a variety of conditions" (Tworek, 2019). Tworek (2019) developed a model of IT reliability in an organisation comprising four components:

- System reliability, which is determined by the availability of the system connected with its security while maintaining proper performance.
- Usage reliability, which is an element of system reliability, determined by the efficiency of system use, its acceptance by the users and ease of use.
- Information reliability, which is determined by easy access to the needed information and its accuracy while maintaining relevance.
- Support service reliability, which is determined by responsiveness and availability of support services for the system.

The importance of IT reliability for contemporary organisations operating under normal conditions was determined by various empirical studies performed and presented in detail by Tworek (2019).

The verification was made among organisations operating in different countries (Poland, Switzerland, the USA and Italy), various industries (e.g., financial) and several points in time. However, the role of IT reliability in organisations operating under the crisis caused by the COVID-19 pandemic has not been sufficiently analysed yet.

Preliminary research on that subject was conducted by Tworek (2020), and based on the analysis of more than 100 organisations that operated in Italy during the first month of the COVID-19 pandemic, it was stated that its role was even more substantial than during normal operating conditions.

It remains in line with the statement by Bieńkowska et al. (2020), who established that all known management paradigms and models need verifications under such conditions to determine whether they can still be useful for organisations.

2.1. IT reliability as a factor mitigating negative effects of organisational performance

The literature coverage of the role of IT support in sustaining organisations during the COVID-19 pandemic is still very limited. However, the available research point to a statement that IT reliability may be an important factor in mitigating the negative effects of the crisis caused by the COVID-19 pandemic on organisational performance. Such mitigation is two-fold: the mitigation of negative effects on (1) job performance and (2) organisational performance.

In this respect, however, organisational performance lacks sufficient literature coverage. Various models are presented in the literature regarding the influence of IT reliability on organisational performance during regular operating conditions. Such a relationship is often recognised in the literature as the IS Success Model (with the DeLone and McLean (2006) model as the best-known example). Most of them include three elements: IT resources, IT capabilities and IT business alignment (Jacks et al., 2011), and all of them have the potential to mitigate various negative effects which may occur in the organisation and negatively influence its performance. Hence, such a point of view may be adopted while analysing the role of IT reliability in mitigating the negative effects of the crisis caused by the COVID-19 pandemic on organisational performance.

The importance of IT support as a resource is undoubtful and clear. The importance of IT capabilities may be supported by some literature reports. The results of the study performed by Wanasida et al. (2021) underline the importance of IT (business analytics) capabilities (determined by reliable IT support) for organisational performance in organisations during the COVID-19 pandemic. They concluded that the higher the organisation's business analytics capabilities (supported by IT), the more agile the organisation (which was also confirmed by Ashrafi et al. (2019)) and, therefore, the better its performance (also confirmed by Darvishmotevali et al. (2020)). Moreover, the research also confirmed the role of information quality (another aspect connected to IT reliability, i.e., information reliability) as a mediator of such relationships, showing its influence on organisational performance. The importance of IT

business alignment comes directly from the need to redesign task implementation and realign the IT to the changed needs of the organisation. Batra (2020) states that the "COVID-19 pandemic serendipitously evoked an era of agility", arguing that achieving such agility in an organisation is predetermined by reliable IT support.

Job performance is discussed in the literature much more often. It is crucial to underline that reliable IT support allowed employees to perform their everyday tasks and maintain a satisfactory level of job performance during the crisis caused by the COVID-19 pandemic (Wang et al., 2020). Authors usually name two IT support-determined factors: support for (1) redesigned tasks and (2) communication.

The need for task redesign came directly from the specificity of the COVID-19 pandemic, which necessitated social distancing and stay-at-home regulations, forcing employees to rethink their task implementation (Gossling et al., 2021). This would not have been possible without IT support. IT allowed organisations to redesign task implementation to continue operations during the COVID-19 pandemic (Wanasida et al., 2021). It was crucial from the point of view of maintaining performance and getting additional help from the government. The loans and guarantees for organisations prepared to mitigate the economic impact of the COVID-19 pandemic are usually subject to their ability for such a business redesign (Mallet & Dombey, 2020).

Moreover, von der Lippe and Lippenyi (2020) stated that reliable IT influences job performance mainly as an enabler for employees to work from home (the need for which plays an immense role in tasks implementation redesign), thus making it key for increasing their organisational commitment and job satisfaction because of the ability to boost motivation.

It is connected to the fact that employees are aware of the reduced possibility to control their work, which rather frequently results in staff feeling more independent, responsible and committed, hence increasing their performance (Kumar et al., 2021).

The need for communication support is also directly related to social distancing and stay-at-home regulations (Gossling et al., 2021). Under such circumstances, communication is almost impossible without required IT support. However, the support does not end there. Hamouche (2020) stated that optimising communication and transparency are key activities which should be implemented by organisations striving to maintain sustainability through the crisis caused by the COVID-19 pandemic. It is needed not only to maintain the possibility to implement tasks and enforce teams (Roberts, 2020) but also to reduce uncertainty for employees and their level of stress and foster positive examples. IT support for working from home is crucial, and the more reliable it gets, the better the possibility of mitigating negative crisis effects.

There are also some other literature reports confirming that virtual work characteristics connected to IT support are the main factors influencing job performance through various mediators, like individual factors (Wang et al., 2020), job insecurity (Tan Vo-Thanh et al., 2021) and wellbeing (Darvishmotevali & Ali, 2020). However, the related literature coverage is scarce and not yet properly established.

Hence, all that reasoning found in the literature covering the issue of organisational performance (and job performance) during the crisis caused by COVID-19 allows for stating that reliable IT support may, in fact, mitigate the negative effects of a crisis on an organisation's operations. Hence, the following hypothesis was formulated:

H2. IT reliability mitigates the negative influence of the crisis caused by the COVID-19 pandemic on organisational performance through job performance.

Moreover, it seems logical to assume that the stronger the negative effects of the COVID-19 pandemic within an organisation (i.e., the deeper the

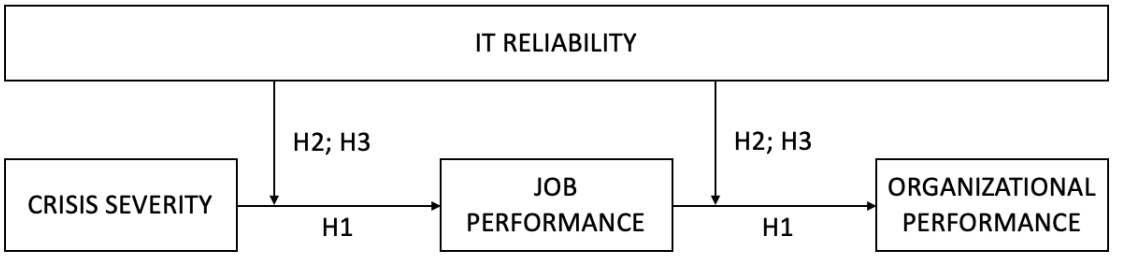

Fig. 1. Overview of research hypotheses

crisis within it), the more crucial the role of IT reliability in mitigating such negative effects. That is because for organisations experiencing minor issues in some operation areas, reliable IT support is key for maintaining high organisational performance in all of the areas, while other areas would perform similarly well without it. However, for organisations experiencing a heavy load of issues in all (or almost all) operation areas, reliable IT support may be the sole determinant of their survival and key resource enabling any organisational performance. Hence, the following hypothesis:

H3. The stronger the negative influence of COVID-19 on organisational performance, the stronger the mitigating influence of IT reliability.

Therefore, based on the reasoning presented above, a set of hypotheses was developed to determine the role of IT reliability in the process of mitigating the negative effects of the crisis caused by the COVID-19 pandemic. The overview of the hypotheses is given in Fig. 1.

3. Research methodology and results

To verify the formulated hypotheses concerning the role of IT reliability in mitigating the negative effects of the COVID-19 pandemic on an organisation, the empirical research was performed as a part of a grant funded by the National Science Centre in Poland (grant No. 2020/37/B/HS4/00130). The empirical research was based on a survey as a measurement tool. The main survey was preceded by the pilot survey conducted in the first quarter of 2020 (Tworek, 2020) with more than 100 organisations (managers responding to the survey acting as competent judges) that operated in Italy at the beginning of the COVID-19 pandemic. According to the obtained results, the final version of the survey was redesigned and amended. The main research was conducted in March 2020, with 1160 organisations from Poland, Italy and the USA. The country of origin was a control variable in the study to verify whether assumed relationships were conditional on any environmental characteristics specific to one region (in the case of pandemic management, economic situation etc.). The sample was selected based on the purchased respondent panel of managers employed at organisations operating in Poland, Italy and the USA. The chosen countries were severely impacted by the COVID-19 pandemic during the survey. Since the empirical studies were aimed at analysing the organisational response to the crisis caused by the COVID-19 pandemic, it was a crucial aspect which needed to be considered.

It was the only aspect limiting the sample. Organisations were surveyed regardless of their size, industry or type of business using the CAWI method. The assumed size of the sample was 1000 organisations. Finally, 1160 responses were selected. Of 1160 organisations, which responded and were included in the sample, 896 organisations stated experiencing the crisis caused by the COVID-19 pandemic, and those were the organisations used for the empirical study (Table 1).

3.1. Variables overview

The empirical research was based on four variables measured with the use of a questionnaire and verified measurement scales.

Tab. 1. Sample characteristics — organisations that operated during the crisis

Organisation's country of origin	Beginning of the crisis	Preparing a recovery plan	Implementing the recovery plan	Total
Poland	75	124	121	320
USA	68	120	212	400
Italy	38	94	44	176
Total	181	338	377	896

Tab. 2. Overview of the variables

Variable	No. of scales	Cronbach's a	Factor analysis	M	SD	VFI
Crisis severity	1			3.21	0.76	1.002
IT reliability	4	0.725	55.049	2.16	0,66	1.259
Job performance	4	0.753	57.759%	2.01	0.63	1.259
Organisational performance	10	0.886	49.426%	3.16	0.74	-

IT reliability was measured based on a 4-item scale concerning all IT solutions used in the organisation, in particular, their system reliability, usage reliability, information reliability and support services reliability. It was measured using a 5-point Likert scale (from "very poor" [5] to "very good" [1] with the middle point "fair").

Job performance was measured based on four aspects: task proficiency, meticulousness in task implementation, work discipline and work improvement and readiness for innovation. It was measured using a 5-point Likert scale (from "very poor" [5] to "very good" [1] with the middle point "fair").

Organisational performance was measured based on a 10-item scale with Balanced Scorecard dimensions (Kaplan & Norton, 1996), allowing to include multiple aspects of organisational performance: financial, customer-related, learning and growth and the internal process. It was measured using a 5-point Likert scale (from "I strongly disagree" [5] to "I strongly agree" [1] with a middle point "I have no opinion").

Crisis severity was measured based on a single-choice question concerning the severity of the crisis caused by the COVID-19 pandemic (in the case of the number of organisations' areas that were affected and the severity of this impact).Crisis occurrence was a variable used for identifying observations within the sample, which should be included in the study.

It was a single-statement and single-choice question concerning the stage of the crisis experienced by the organisation at the time of the survey (with an option "the organisation is not in crisis").

First, it was established that the collected data were characterised by the normal distribution. Second, the scale analysis was performed to verify whether they could be used in the study and coherently and correctly assess the analysed phenomena. The descriptive statistics for those variables are presented in Table 2, together with the results of the reliability of scales analysis (Cronbach's alpha values were above 0.8, which shows sufficient reliability and coherence of used measurement scales and allows to form conclusions based on such data). Moreover, the VFI coefficient was calculated for each variable (Table 2) and demonstrated the absence of a co-linearity issue between analysed variables, and linear regression models can be built to perform statistical reasoning.

3.2. Research results

Saks (2006) indicated three conditions required to establish a linear regression model with a mediator. First, the independent variables must be related to the mediator. Second, the dependent variables must be related to the mediator. Third, a significant relationship between the independent variables and dependent variables has to be reduced (partial mediation) or made no longer significant (full mediation) when controlling for the mediator. To verify whether the conditions are satisfied, the Pearson's correlation (r) analysis was performed after the normality test confirmed the possibility of performing the analysis. The results are presented in Table 3.

The obtained results showed a statistically significant but weak correlation between all analysed variables, which allowed for starting a verification of the mediation occurrence within the assumed model. Since such a conclusion enables the next step, the linear regression model with a mediator was built using the Hayes' PROCESS macro designed for IBM SPSS Statistics software (Model 4) for crisis severity as an independent variable, organisational performance as a dependent variable and job performance as a mediator. The obtained regression model was statistically significant, and its fit was sufficient for the statistical reasoning ($F(2.859)=28.269$ and corrected $R2=0.248$). The results concerning the mediation effects are included in Table 4.

Hence, job performance was indicated to be a statistically significant mediator of the model ($p<0.001$, coeff. = 0.284, se = 0.038). The obtained model shows that job performance is indeed a mediator of the relationship between crisis severity and organisational performance, which allows accepting hypothesis H1.

However, since the value of R2 is quite low and organisational performance is a variable with a very high degree of aggregation, the regression model with control variables was calculated to determine whether the elements proposed in the model remained a statistically significant predictor of organisational performance while considering other aspects of organisational operations. The results of regression analysis confirmed that IT reliability and job performance were statistically significant elements of the model, which includes control variables (V1–V6 concerning the organisational structure, culture, technology, human capital and goals) describing elements of the organisation distinguished by the Leavitt

Tab. 3. Correlation analysis between the analysed variables

		Job Performance	Organisational Performance
Crisis severity	r	0.206	0.092
	Sig.	<0.001	<0.001
	N	890	864
Organisational performance	r	0.246	1
	Sig.	<0.001	
	N	865	864

Tab. 4. Linear regression analysis with a mediator — results

Mediator	Direct effect value	Indirect effect value	BootLLCI	BootULCI	R2
Job performance	0.028	0.212	0.008	0.394	0.248

Tab. 5. Linear regression analysis with the moderator — results

Model description	R^2	Delta R^2	Moderator coeff.	Standard error	t Stat	P Value
Crisis severity, moderator: IT reliability, dependent v.: organisational performance	0.463	0.083	0.111	0.037	3.565	0.0027*
Crisis severity, moderator: IT reliability, dependent v.: job performance	0.268	0.005	0.037	0.052	0.705	0.480

**accepted level of significance 0.001*

model. Hence, the statistical reasoning presented above may be used for further analysis and to form conclusions.

After establishing that the statistical reasoning can be implemented based on acquired data, to verify the hypotheses concerning the moderation effect of IT reliability, the linear regression model with the mediator (job performance) and the moderator (IT reliability) was built using Hayes' PROCESS macro designed for IBM SPSS Statistics software (Models 7 and 14). The results of the analysis are presented in Table 5.

The linear regression analysis with the mediator and the moderator allowed for various conclusions. First, the models allowed for statistical reasoning based on them since they were both statistically significant and sufficiently fitted: the relationship between crisis severity and job performance ($F(3.850)=77.465$, $p<0.001$) and the relationship between job performance and organisational performance ($F(4.849)=16.533$, $p<0.001$). However, IT reliability proved to be a statistically significant moderator only in the case of the first relationship. Therefore, based on the obtained results, hypothesis H2 should be accepted (as at least one of the relationships within the mediation model was moderated by IT reliability). Moreover, as the results showed a positive cause–effect relationship between the analysed variables within the linear regression model with the mediator and the moderator and at least one of the moderation hypotheses was accepted, there is also sufficient data to accept the hypotheses H3.

4. Discussion

As stated before, organisational performance is at the centre of attention for organisations that strived for sustainability during COVID-19 (Lozano & Barreiro-Gen, 2021). Moreover, job performance related to individual employee performance seemed to be just as important in the process of obtaining and maintaining such sustainability. Hence, the obtained results allow verifying that IT reliability indeed mitigated the negative effect of the crisis caused by the COVID-19 pandemic on organisational performance (through job performance), determining the organisational sustainability (measured based on the Balanced Scorecard approach, connected to various aspects of organisational operations and including the sustainability point of view to some extent).

The obtained results demonstrate that IT reliability is a moderator of the mediation model between the crisis severity and the organisation's performance,

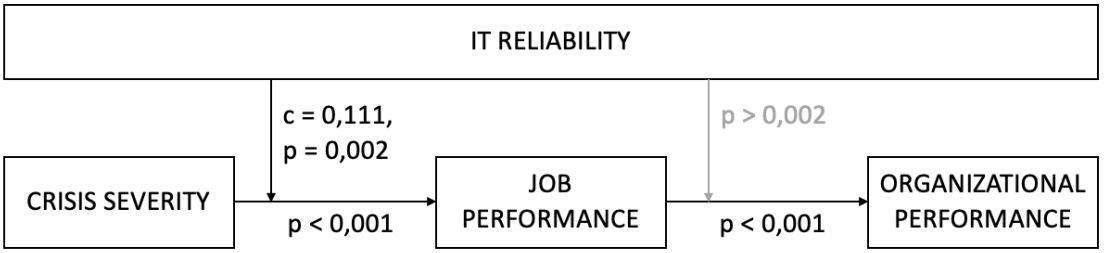

Fig. 2. Research results

mediated by job performance. Most importantly, the moderation effect occurs within the first part of the model for the relationship between the crisis severity and job performance (Fig. 2). Hence, the obtained results allowed to verify various statements found in the literature, in which authors hypothesised that reliable IT support would mitigate various negative effects of crisis caused by the COVID-19 pandemic on job performance (Wang et al., 2020; Gossling et al., 2021; Wanasida et al., 2021), enabling tasks redesign (mainly through the support for working from home (von der Lippe & Lippenyi, 2020)) and maintaining positive job-related attitudes (Tan Vo-Thanh et al., 2021). Also, or even above all else, they allow for a conclusion that during the crisis caused by the COVID-19 pandemic, employees and their job performance was crucial for obtaining and maintaining organisational performance (measured in a way which allows it to reflect on organisational sustainability) and should be treated as the most important resource of an organisation.

Moreover, the obtained results allow for a conclusion that the more severe the crisis within an organisation, the larger the mitigating strength of IT reliability. It should be noted that it is a very important conclusion showing that organisations should focus on boosting IT reliability at the beginning of the crisis because its role in ensuring organisational sustainability grows during the crisis development.

Moreover, it must be underlined that IT reliability was verified as an important factor in mitigating the negative effects in organisations operating in all analysed countries (Poland, Italy and the USA). It allows for a conclusion that its role does not depend on any specific environmental characteristic (the country of origin was used as a control variable). Based on these conclusions, considerations offered during the hypotheses development are true for contemporary organisations regardless of their economic circumstances.

Conclusions

The article concerns IT reliability's role played in shaping organisational sustainability during the crisis caused by the COVID-19 pandemic. The article mainly aimed to determine whether IT reliability mitigated the negative effect of the crisis on organisational performance (through employee job performance) in organisations during the COVID-19 pandemic. The aim was successfully reached, which allowed the addressing of an existing research gap concerning the lack of empirical studies in this regard. The obtained results allowed for forming general conclusions on the subject as the survey was conducted with organisations that declared experiencing the crisis caused by the COVID-19 pandemic and operating in various economic circumstances (in Poland, Italy and the USA). IT reliability was verified as an important factor in mitigating the negative effects in organisations operating in all surveyed countries, showing that its role does not depend on any specific environmental characteristics. Therefore, a substantial contribution to the theory concerning IT use in contemporary organisations (especially during a crisis caused by a Black Swan type of event) was made.

Moreover, the conducted empirical research has some practical implications, determining that contemporary organisations striving to survive the COVID-19 pandemic and maintain their sustainability should have focused on the reliability of IT used in their organisations, not only just their implementation. It is important to underline that a high level of IT reliability had the potential to mitigate the negative

effects of the crisis caused by the COVID-19 pandemic on job performance, which seems to be a key relationship for maintaining organisational sustainability.

The performed research has some limitations as the conclusions were established based on a limited number of organisations, which is not a representative sample (given the sampling method). However, the sample was big and sufficiently diversified (the study included three countries and more than 1000 organisations) to justify conclusions based on the given results. Moreover, the study showed the future directions of research, which should be connected with determining the mechanisms through which IT reliability mitigated the negative effect of the COVID-19 pandemic on job performance, indicating methods for boosting those mechanisms and obtaining more benefits from them.

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Exploring the critical success factors of a resilient supply chain

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ABSTRACT

This study aims to identify and analyse critical success factors (CSFs) for an organisation aiming for a resilient supply chain. The methodology followed is the systematic analysis of big databases, such as Emerald, Science Direct, and Taylor & Francis, by using a specific set of keywords for filtering. The systematic literature review leads the author to the exploration of several CSFs, followed by their prioritisation by using principal component analysis. The paper highlighted eleven vital CSFs: top management commitment, development of an effective SCM strategy, logistics synchronisation, use of modern technologies, robust information and communication technology, information sharing with SC members, collaborative partnership, improved forecasting, trust development in SC partners, collaborative partnership, strategic partnership, development of reliable suppliers, continuous improvement in the preparedness and response practices, capacity building and training and staff development. The CSFs highlighted in the paper relate to all small and medium-sized enterprises (SMEs). This paper identifies the CSFs for developing a resilient supply chain that is comprehensive and has the potential to address uncertain circumstances. This work is the first of its kind on CSF assessment and categorisation in resilient supply chains.

KEY WORDS

resilient supply chains, critical success factors (CSFs), small and medium enterprises (SMEs), systematic literature review (SLR), principal component analysis (PCA)

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Introduction

The expanding recurrence and effect of sudden catastrophic events have driven analysts and experts to move from conventional hazard management techniques to deal with the resilient approach (Jüttner & Maklan, 2011; Pettit et al., 2013). Resilience empowers frameworks to adapt to the unforeseen (Vegt et al., 2015) and guarantee congruity of tasks and conveyance to conclusive clients (Christopher & Peck, 2004; Ponomarov & Holcomb, 2009; Stone & Rahimifard, 2018). Although resilience appears to connect all associations in a system, it has to be

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researched how each part adds to the general process, such as with regard to supply chains. The study aims to identify and analyse critical success factors (CSFs) for an organisation aiming for a resilient supply chain.

The methodology followed is a systematic analysis of big databases, such as Emerald, Science Direct, and Taylor & Francis, using a specific set of keywords for filtering. The systematic literature review leads the author to explore several CSFs, followed by their prioritisation by using principal component analysis. The study identifies comprehensive CSFs for developing a resilient supply chain and having the potential to address uncertain circumstances. This work is the first of its kind on CSF assessment and categorisation in resilient supply chains.

1. Literature review

1.1. Supply Chain Management (SCM)

The term "supply chain" refers to the effective collaboration of interconnected business enterprises (Christopher & Peck, 2004; Håkansson & Snehota, 1989).

According to Stock & Lambert (2000), supply chain management is "the integration of key business processes, from end-user through original suppliers, that provides products, services, and information that add value for customers". Supply chain management can be defined as the collaboration of upward and downward integration of organisations during different processes to maximise the value of the end product/service (Mentzer et al., 2001; Szpilko, 2017).

1.2. Risks

"Risk" and "uncertainty" are two key terms that have to be countered in a resilient system. The risk may be termed as an unplanned event, whereas uncertainty leads to situations where the implications are not completely known.

Discussing the most important risks, Hessam ZandHessami & Ava Savoji (2011) underlined environmental, financial, strategic, informative and communicative technology, technology and equipment, HR, and supply chain risks. They found environmental risks to be the most impactful and significant because of measures and guidelines imposed by the central administration.

There are two sorts of risks: internal and external. Internal dangers include late conveyances, the overabundance of stock, poor gauges, money-related threats, minor mishaps, man-made errors and blame in data innovation frameworks. External dangers begin outside the inventory network, for example, earthquakes, floods, tsunamis, wars, deficiency of crude materials, and financial irregularities (Jaeger, 2010; Mandal 2016).

As defined by Jabbour & Thomas (2015), a risk is "a conceivably horrendous accident that is by and large experienced, has an intense beginning, what's more, is time delimited; fiascos might be credited to regular, innovative, or human cause".

Vulnerability and other related terms like risks, uncertainty, and reliability were coined together to formulate supply chain risk management (Svensson, 2000). Resilience is a bridge between disaster risk management and sustainable communities (Mari

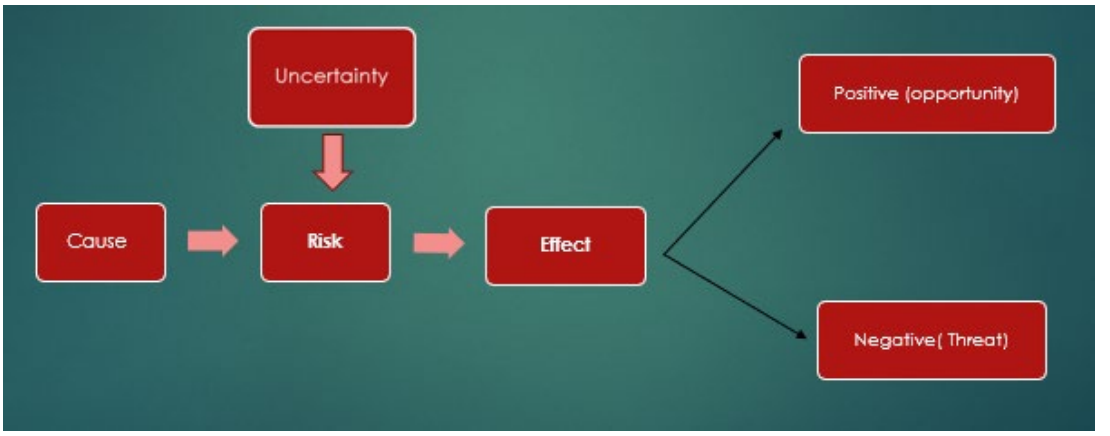

Fig. 1. Risk management model
Source: Korecký, 2012.

Tab. 1. Risk types

Risk	Internal	External	Author
Supply risk	√		Asad et al., 2019; Jüttner, 2005; Paul et al., 2016; Wagner & Bode, 2008
Process risk	√		Paul et al., 2016; Shahbaz et al., 2019; Wagner & Bode, 2008
Demand risk	√		Manuj, 2008; Paul et al., 2016; Rao & Goldsby, 2009
Logistic risk	√		Punniyamoorthy et al., 2013; Syamsyul Bin Rakiman et al., 2018; Thun & Hoenig, 2011; Wang et al., 2014; Zubair & Mufti, 2015
Collaboration risk	√		Pradesh, 2009; Syamsyul Bin Rakiman et al., 2018; Thun & Hoenig, 2011
Financial risk	√		Musa, 2014; Pradesh, 2009
Environment		√	Knemeyer et al., 2009; Wagner & Bode, 2008; Xu et al., 2020; Zsidisin et al., 2016

et al., 2014). Supply chains of organisations can be disturbed by a variety of human-made and natural events, for example, earthquakes, political unrest, fuel emergencies, epidemics, and dictatorships (Fiksel, 2006). Due to natural disasters, risks have always been the main issue in discussing supply chain management (Kbah, Erdil & Aqlan, 2020).

Different risk management models are discussed in the literature, and a widely popular one was proposed by Korecky, as shown in Fig. 1.

Multiple risk types are identified in Table 1 and are broadly categorised as internal or external risks.

1.3. Resilience

An average production network can fall short for many reasons, such as inaccessible raw materials or unreliable equipment; issues with product purity or business reputation; government regulations or unrest; value, theft, or pandemics. Such dangers can either harm an organisation, crush it or make it more grounded (Fiksel et al., 2005). Different definitions taken from the literature for the term "resilience" are given in Table 2.

1.4. Supply Chain Resilience (SCRES)

Supply chain resilience (SCRES) is another insufficiently explored topic. The above-stated events have prompted academia and SCM practitioners to minimise their damage by developing more resilient supply chains. Christopher & Peck (2004) and Sheffi et al. (2003) worked on the concept of SCRES and coined the earliest definitions of resilience. Soon after, considerable research was done by applying multiple techniques, such as case studies, questionnaire surveys, conceptual/theoretical work, modelling and visualising using alternative theoretical lenses.

Multiple resilience frameworks are discussed in the literature, one of which is given below in Fig. 2

1.5. Systematic literature review (SLR)

No academic research is complete without conducting a thorough literature review. Work performed by other scholars builds a fundamental base for advancing knowledge. A deep study of the existing literature helps to identify unexplored topics.

Tab. 2. Different definitions of resilience

Definition	Author
The capability to anticipate and overcome disruptions	Ambulkar et al., 2015; Gerhold et al., 2019; Pettit et al., 2010, 2013
"Strength is the capacity of a worldwide production network to revamp and convey its centre capacity ceaselessly, regardless of the effect of outside and additionally inner stuns to the framework"	Global Risks Report: World Economic Forum, 2011
"The capacity of a framework to come back to its unique [or desired] state after being upset"	Christopher & Peck, 2004
"The capacity to keep up yield near potential in the result of stuns"	Duval et al., 2011
"Resilience is commonly described as the ability to bounce back or overcome some form of adversity and thus experience positive outcomes despite an aversive event or situation"	ShaeLeigh Cynthia Vella, 2019
"Resistance refers to a material, member, or system's ability to safely sustain load"	Rosowsky, 2020

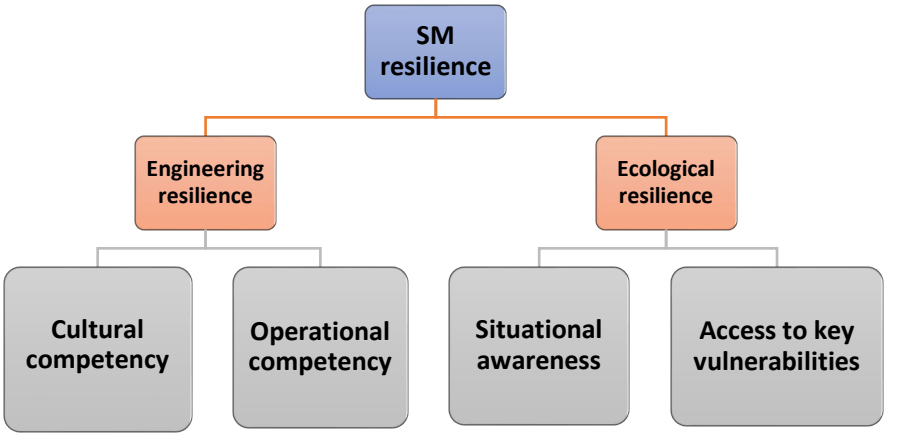

Fig. 2. Framework for SM Resilience
Source: Eltanwy, 2015.

Once identified, a gap can be used to test certain hypotheses and develop new theories or to identify any inconsistency or contradictions in the existing body of knowledge (Paré et al., 2015). In the past, a literature review was done in a traditional narrative manner and was later replaced by a systematic review, which is comprehensive and more reliable. One of the most sought-after methods for studying past research is a systematic literature review (SLR), as it tends to be transparent and eliminates possible biases (Tranfield et al., 2003). This article aims to conduct a systematic literature review on developing a comprehensive framework for resilient supply chains.

1.6. Critical Success Factor (CSF)

CSF theory originates in the works of Daniel (1961) and Rockart (1982). Daniel theorised that information systems must focus on "success factors" and argued that in most industries, there are "usually three to six factors that must be performed exceedingly well for a company to be successful". Rockart (1982) defined CSFs as performance factors determining where management attention should focus.

Awareness of CSFs can guide organisations in implementing a new management concept, methodology, technology, regulation etc. (Näslund, 2013). CSFs can be categorised as soft, e.g., behavioural, cultural, or management, and as hard, e.g., quantifiable or tools (Ismyrlis & Moschidis, 2013).

CSFs can direct an organisation's strategic planning, implementation of a plan, and achievement of high performance (Boynton & Zmud, 1987). Scholars and practitioners (Kwak & Anbari, 2004; Pinto, 1986; Rosacker et al., 2010) from project management and quality management fields have acknowledged the need to determine CSFs before implementing a project methodology.

CSFs are defined as "factors essential to the success of any program or technique, in the sense that, if objectives associated with the factors are not achieved, the application of the technique will perhaps fail catastrophically" (Setijono et al., 2012).

"CSFs are critical areas of activity that require focus to ensure competitive performance towards an organisation's strategic goals" (Liu et al., 2015). One of the major focuses of process management for business success is performance improvement. CSFs are the key to process management success. Identifying and categorising CSFs as per their importance assists in creating value and aids stakeholders in cutting down undesirable results in their endeavours (Almarri & Boussabaine, 2017).

1.7. Gap analysis

Resilience empowers frameworks to adapt to the unforeseen (Vegt et al., 2015) and guarantee congruity of tasks and conveyance to conclusive clients. Although resilience appears to connect all associations in a system, it has to be researched how each part adds to the general process, such as concerning supply chains.

The World Economic Forum (2013) uncovered that over 80 % of organisations are worried about the versatility of their inventory chains. As companies "leaned out their operations, they began to realise that the strategies they have been practising are not protecting them from failure in the face of increasingly volatile conditions" (Mason-Jones et al., 2000).

"The shrinkage of the supply chain due to increased outsourcing made the organisations dependent on suppliers, whereas the emphasis on Just-in-Time strategies and Six Sigma cut down on buffers and decreased flexibility" (Revilla & Jesus, 2017).

Businesses around the world try to make their supply chains resilient in response to natural or industrial "low-frequency, high-impact" (LFHI) risks. These LFHI risks cause an interruption in the downstream supplies and may result in the closure of production and distribution activities in various SCs (Hald & Kinra, 2019; Hosseini et al., 2019; Ivanov, 2020). COVID-19 has clearly shown how resilience is the single most important trait for supply chain performance.

Remko (2020) pointed out a dire need for more empirical models which can help industries to build more resilient supply chains. Ivanov (2020) stated that resilience is one of the prime factors for the development of viable supply chains.

Singh et al. (2021) also emphasised that the resilience of the public distribution system (PSD) for essential items, such as food grain supply, came smashing down in disastrous events, such as COVID-19, which signifies the need for research identifying a framework that would help industries to withstand such disasters in the future.

Belhadi et al. (2021) identified that a collaborative risk management strategy should be developed for all levels of a supply chain, and SOPs need to be prepared for outbreaks. A systematic literature review was conducted to determine the need for more studies to increase the theoretical base, which may lead to new theory building. Wieland (2021) opened more doors to the SCM and called for more advanced and adaptable frameworks for resilience.

Supply chain management research also emphasises the need to bridge the gap between research practices in supply chain risk management. As evident from the cited literature, a clear need exists for a refined empirical framework that is based on observed and measured phenomena rather than theory or belief for developing a resilient supply chain. It will be covered in this study.

2. Methodology

2.1. Systematic literature review (SLR)

Inclusion criterion. Topics of the selected articles ranged from those emphasising supply chain management, resilient supply chains, and making supply chains resilient. Only articles written in English were included.

Literature identification. The following keywords were used for the review: "resilient supply chains", "risks", "framework", and "critical success factors". For each of the articles listed first, their relevance was checked by reading the manuscript title. Based on the analysis of the title, provided the document seemed to discuss the concept of CSFs in the domain of resilience, it was to be taken into consideration. The full reference was recorded, including the author, year of publication and abstract of the article. Aiming to review the maximum literature available in the scholarly world, the research targeted articles published during 1995–2021, as the terms "supply chain" and "risks" appeared in the literature in 1995. This was done to identify literature gaps. Three databases were searched: Emerald, Science Direct, and Taylor & Francis (Tranfield et al., 2003). After initial screening, which included checking the title and abstract, 70 articles were found fit for the review. The SLR process is depicted in Fig. 1.

Screening for inclusion. The abstracts of the 70 articles which passed the inclusion criteria were read to decide on their relevance for the review. A total of 56 studies were considered relevant, and their full texts were used. Quality and eligibility assessment. The full articles were thoroughly read to examine their quality and how they could serve the study's objective. Technical reports were included for review too.

Iterations. A backward and forward search was also done to identify some review methods. Best practices were set by analysing articles that followed the same methodology. The articles concentrating on the CSFs adopted by different industries to enhance their supply chain performance were preferred. Overall, this led to forty-six articles in total.

2.2. Data extraction and analysis

All of the articles selected for the study were scanned considering two points: (1) the antecedents for constituting the framework and (2) the CSFs that were set to enhance the performance of the supply chain. The N-Vivo software was used for data extraction and coding.

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3. Discussion and analysis

Nam et al. (2020) derived indicators through literature for their study. The same procedure is applied,

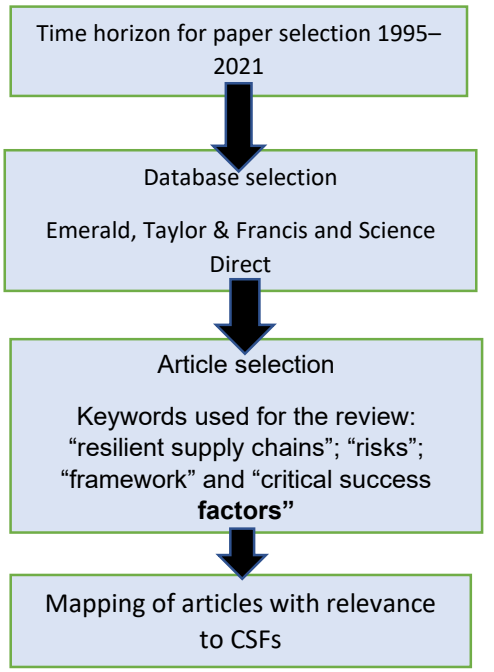

Fig. 3. Flow diagram of systematic literature review

and critical success factors for mitigating supply chain risks are extracted.

Multiple themes were developed using the N-Vivo software. The scholarly inclination toward these themes was recorded and tabulated in Table 4. The identified themes are mentioned in the following text. Fig. 4 and Table 3 exhibits various CSFs that were found in the literature search. The most popular was the use of modern technology, with a weight of 21 %.

3.1. Principal component analysis (PCA)

Work needs to be done on decreasing the number of variables to make the framework less complex by utilising techniques that reduce nonlinear dimensionality (Van Der Maaten et al., 2009).

In total, thirteen dimension-reduction techniques were identified in the literature. However, principal component analysis (PCA) performs better than others. As Van Der Maaten et al. (2009) con-

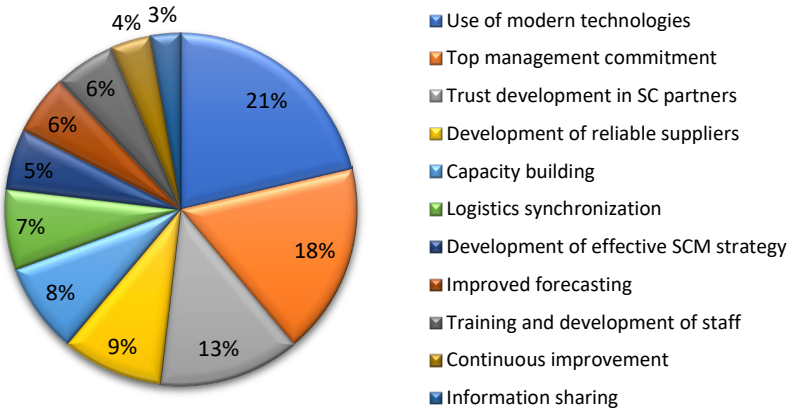

Fig. 4. Various CSFs used in resilient supply chains

Tab. 3. Critical Success Factors

CSF No.	Critical Success Factor
1	Top management commitment
2	Development of an effective SCM strategy
3	Logistics synchronisation
4	Use of modern technologies (robust information and communication technology)
5	Information sharing with SC members, collaborative partnership
6	Improved forecasting
7	Development of trust in SC partners, collaborative partnership, strategic partnership
8	Development of reliable suppliers (coordination and collaboration with other organisations
9	Continuous improvement in the preparedness and response practices (implementing the lesson learned from previous events)
11	Staff training and development
10	Capacity building (mock drill, training, house preparedness, first aid preparedness, etc.)

Tab. 4. Critical Success Factors for Resilient Supply Chain Risk Management

S. No.	Authors	1	2	3	4	5	6	7	8	9	10	11
1	Chowdhury et al., 2020								√			
2	Luo et al., 2018									√		
3	Mendoza-Fong et al., 2018				√							
4	Kausar et al., 2017								√			
5	Moktadir et al., 2017	√										
6	Kaneberg et al., 2016								√			
7	Yadav & Barve, 2015			√	√		√			√	√	
8	Ramanathan et al., 2014								√			
9	Zhou et al., 2014		√	√							√	
10	IAG Odisha, 2014*								√			
11	OSDMA, 2012; 2013; 2014*			√							√	
12	Ab Talib & Hamid, 2014	√			√	√		√				√
13	Lin et al., 2013	√	√		√				√			
14	Dinter, 2013	√			√	√						
15	Thakkar et al., 2013	√		√	√			√				√
16	UNEP, 2013*											√
18	Korecký, 2012											√
19	Mothilal et al., 2012				√				√			
20	Kim & Rhee, 2012				√	√	√	√				
21	Hoejmose et al., 2012	√										
22	Zhou et al., 2011		√	√	√		√					
23	Koh et al., 2011				√			√	√	√	√	
24	Oloruntoba, 2010		√				√		√		√	
25	Hu et al., 2010	√										
26	Sandberg & Abrahamsson, 2010	√										
27	Hu et al., 2009				√			√				
28	Nair et al., 2009				√							
29	Cullen & Taylor, 2009				√							
30	Pettit & Beresford, 2009	√	√	√	√		√	√		√	√	√
31	Rao Tummala et al., 2006				√			√				
32	Davidson, 2006		√				√		√			

33	Fawcett et al., 2006	√			√			√				√
34	Angappa Gunasekaran & Ngai, 2004	√			√							√
35	Soin, 2004	√			√							
36	Ngai et al., 2004				√			√				
37	Chen & Paulraj, 2004	√			√			√				
38	Gunasekaran & Ngai, 2003	√		√	√							
39	Cai & Jun, 2003	√										√
40	Power et al., 2001	√			√			√				√
41	Tate, 1995											
42	Chiu, 1995	√		√				√				
		19	**6**	**8**	**23**	**3**	**6**	**14**	**10**	**4**	**6**	**9**

* Inter-Agency Group (IAG) is a consortium of INGO & UN agencies, ensuring minimum humanitarian standards in disaster risk reduction and management.

cluded, PCA is considered one of the best techniques for dimension reduction compared to the existing nonlinear techniques. The pros of using PCA for categorising the CSFs are that it does not apply weights to all CSFs randomly but rather does the multivariate statistical study of the variables, which increases the data's robustness (Narula & Reddy, 2015). The PCA is an informative data technique that allows data structure to be revealed (Abdullah et al., 2020).

To ascertain if PCA can be applied to this data set, Kaiser–Meyer–Olkin (KMO) and Bartlett's test was conducted to confirm the data adequacy for PCA. The KMO result was .595 (greater than 0.5), the chi-square value — 127.873, and a significance value — 0.000 (lower than 0.05, i.e., a confidence level of 95%), as discussed in Table 5. The CSFs were distributed in four new groups, and each group's weight was calculated along with the weight of individual CSFs. These four new CSFs can now be computed for the range of data that will be researched. This will help in the calculation of the performance of the organisation.

Tab. 5. KMO and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy	.595
Bartlett's test of sphericity approx. chi-square	127.876
df	55
sig	.000

3.2. Factor loadings

The factor loadings normally range from -1 to +1 and indicate how much explanation is given by each factor in defining a variable. The pattern of the loading was examined to determine the influence of factors on each variable. A strong influence was demonstrated by factors that have loads closer to -1 or +1, whereas loading values closer to 0 indicated that the factor had a weak influence on the variable. Though, some variables may have high loadings on more than one factor.

Loadings that are difficult to interpret are the un-rotated factor loading. When the factors are rotated, this makes the loading structure simpler and helps make the factors easier to interpret and become more distinguishable. Table 6 helps in the examination of the factor loadings.

A varimax rotation allows researchers to interpret values that are difficult when the factors are not rotated. Now, interpretation is easier, and the following things can be noted:

- Logistics synchronisation (.277), capacity building (.274), and continuous improvement in the preparedness and response practices (.256) are big positive loadings on factor 1, so the following factors elaborate continuous working towards the logistical network.
- Trust development in SC partners, collaborative partnership, strategic partnership (0.415), and use of modern technologies (.341) comprise the most loadings on factor 2, so the factor elaborates on the use of technology in developing collaboration among SC partners.
- Development of reliable suppliers (coordination and collaboration with other organisations
- (-0.349) and use of modern technologies (0.299) greatly impact the loadings on factor 3, so the factor elaborates on the use of technology to develop trustworthy suppliers.
- Top management commitment (0.456) and staff training and development (0.212) are big positive loadings on factor 4, so the factor elaborates on how top management helps develop their staff.

Tab. 6. Rotated component matrix – extraction method: principal component analysis; rotation method: varimax with Kaiser normalisation

	Raw			
	Component			
	1	2	3	4
Top management commitment	-.070	.029	.101	.456
Development of an effective SCM strategy	.244	-.053	-.094	.032
Logistics synchronisation	.277	-.043	.146	.072
Use of modern technologies (robust information and communication technology)	.047	.341	.299	-.096
Information sharing with SC members, collaborative partnership	-.020	.075	.029	.007
Improved forecasting	.256	.017	-.021	-.047
Trust development in SC partners, collaborative partnership, strategic partnership	.036	.415	-.003	.041
Development of reliable suppliers (coordination and collaboration with other organisations)	.034	-.072	-.349	-.105
Continuous improvement in the preparedness and response practices (implementing the lesson learned from previous events)	.155	.040	.010	-.028
Capacity building (mock drill, training, house preparedness, first aid preparedness, etc.)	.274	-.018	-.013	-.029
Staff training and development	.020	.230	-.011	.212

3.3. Communality

Communality can be described as the proportion of variability generated by each variable that is explained by the factors. The commonality value remains the same irrespective of the loading factors being rotated or unrotated.

A careful examination demonstrated that each variable had a significant role in explaining the factors. The closer a communality value to 1, the better the variable is explained by the factors, as evident from Table 7.

3.4. Variance

The variation in the data set is explained by each factor. The variance created by each factor is equal to the eigenvalue if unrotated loadings are used during the extraction method of principal component analysis. The summation of the variation, as explained by factors, remains unchanged, although the rotation of the loadings may change the distribution of the proportion of variations.

A careful examination of the variance of each factor demonstrated that the higher the value of the variance, the more influence it has on the variability of the data set.

Next, the question arose of how many factors should be extracted for the analysis. The PCA method without rotation uses the default number of factors as a preliminary assessment. Later, the important factors were defined as those having a variance value greater than a set value. Table 8 provides more information.

Tab. 7. Communalities – extraction method: principal component analysis

	Initial	Extraction
Top management commitment	1.000	.723
Development of an effective SCM strategy	1.000	.805
Logistics synchronisation	1.000	.663
Use of modern technologies (robust information and communication technology)	1.000	.685
Information sharing with SC members, collaborative partnership	1.000	.682
Improved forecasting	1.000	.799
Trust development in SC partners, collaborative partnership, strategic partnership	1.000	.566
Development of reliable suppliers (coordination and collaboration with other organisations)	1.000	.577
Continuous improvement in the preparedness and response practices (implementing the lesson learned from previous events)	1.000	.646
Capacity building (mock drill, training, house preparedness, first aid preparedness, etc.)	1.000	.740
Staff training and development	1.000	.485

Tab. 8. Total variance explained – extraction method: principal component analysis

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
Raw						
1	.474	27.987	27.987	.474	27.987	27.987
2	.328	19.376	47.363	.32	19.376	47.363
3	.246	14.523	61.886	.246	14.523	61.886
4	.163	9.646	71.532	.163	9.646	71.532
5	.119	7.030	78.562			
6	.096	5.669	84.231			
7	.086	5.056	89.287			
8	.068	4.042	93.329			
9	.050	2.976	96.304			
10	.040	2.375	98.679			
11	.022	1.321	100.000			
Rescaled						
1	.474	27.987	27.987	2.347	21.340	21.340
2	.328	19.376	47.363	2.432	22.109	43.448
3	.246	14.523	61.886	1.321	12.008	55.457
4	.163	9.646	71.532	.911	8.278	63.735
5	.119	7.030	78.562			
6	.096	5.669	84.231			
7	.086	5.056	89.287			
8	.068	4.042	93.329			
9	.050	2.976	96.304			
10	.040	2.375	98.679			
11	.022	1.321	100.000			

4. Discussion

A structured version of a small-group debate to obtain consensus is known as a nominal group technique (NGT). NGT asks participants to react to questions presented by a moderator before asking them to rank the thoughts or suggestions made by each group member. The NGT groups offer more original ideas than interactive groups, more evenly distributed participation among group members, a greater feeling of success, and better satisfaction with the calibre of ideas and group productivity. NGT was modified by Bartunek & Murninghan (1984), which aids in handling a poorly organised discussion. The facilitator asks if the ideas apply to the same topic after the usual thoughts are developed and listed. If not, the issue is deemed poorly structured, and the thoughts are grouped into coherent groups. This greatly helps in developing accountability for the problem and, thus, aids in fixing the issue. In the case discussed in this article, the authors, with the consensus of the experts, developed four main themes of the CSFs. Hence, it became easier for the organisation to design a foolproof system or a resilient system with the bare minimum risks.

Through the consensus, CSFs were categorised into four major groups. The top management and strategic role can be implemented by the strategic managers, while an SC partnership needs to be developed by the tactical management, whereas the use of modern technologies needs to be set up by the operational level as well so that they know how exactly to work in the event of a disaster.

The experts emphasised the importance for the top management to enforce effective measures allowing for the design of the supply chain with the primary focus on the resilience goal. Therefore, the decision-making approach must be top-down. Measures must

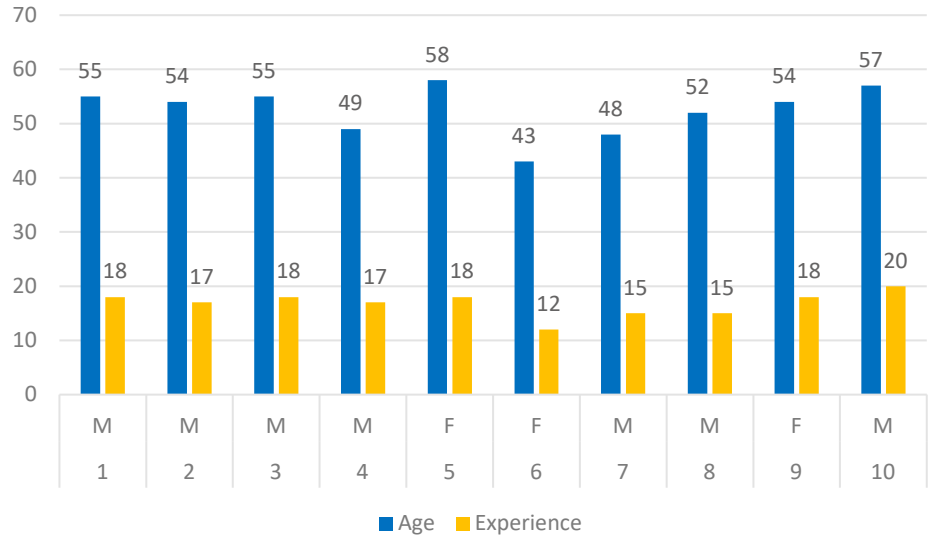

Fig. 5. Age and experience of experts

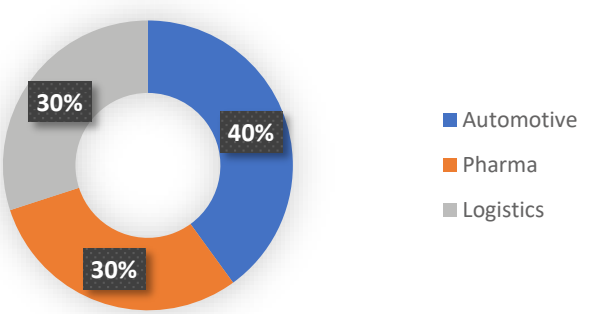

Fig. 6. Sectors represented by experts

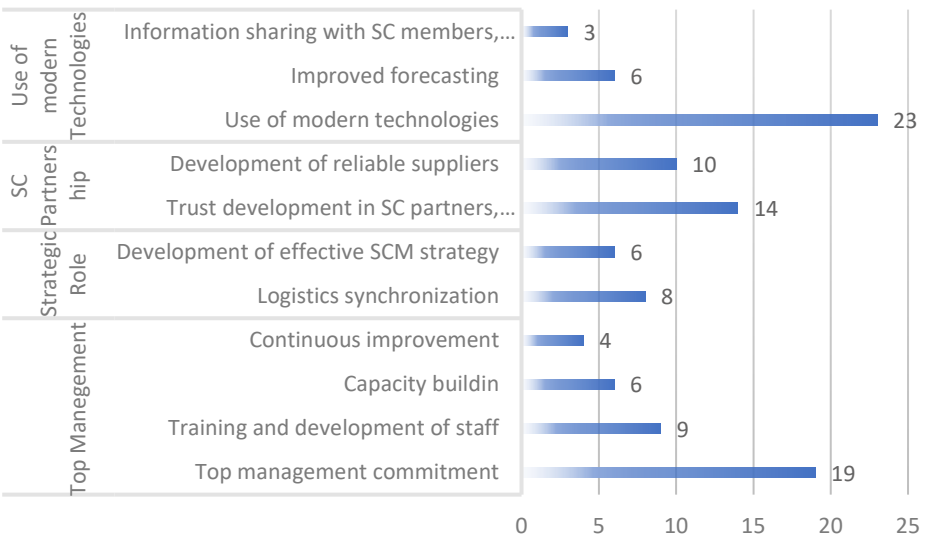

Fig. 7. Four Major CSF Domains of A Resilient Supply Chain

be created to develop a fool-proof system, and staff training and development must be regular and not only in events of disaster but throughout the year. Capacity building becomes an integral part of strategic decisions so that this capacity can be utilised in events of unforeseen risks. Continuous improvement strategies have become the norm after lean manufacturing practices.

The second task that strategic management needs to work on is the role played in strategic management. Designing features like Keiretsu, where a group of vendors is selected and is financially and technologically aided by the parent organisation, are doing wonders for vendor relationship management. This is a win–win situation for both parties. Logistics Synchronisation is a widely used term in logistics systems, and it promises to increase efficiency by coordinating supply and demand over time and space.

The second — tactical — level develops the SC Partnership. Developing good relationships with vendors goes a long way. For this purpose, an effective SCM strategy needs to be in place. A vendor management system needs to be top-notch. Annual vendor conferences have become a regular practice. These conferences help the tactical management in rating their vendors, which helps in determining the vendors fit for such programmes as Keiretsu.

The third — operational — level requires the practical use of modern technologies. Unless the organisation has well-organised demand, supply, supplier and vendor information, it will not be able to fulfil orders on time, especially in events of disruption.

Conclusion

This study examines journal papers published between 2010 and 2022. The SLR approach helped in exploring and analysing how various CSFs for small and medium enterprises are combating the effects of risks. Three major databases were selected, and various keywords were used to identify the most significant studies relating a supply chain with CSFs. A comprehensive list of the most fundamental CSFs was compiled in this manner. The study has offered a thorough list of critical factors found in the literature, together with their definitions, using a conceptual mapping categorisation methodology. It is evident from the study that some very important CSFs, such as the use of modern technologies and top management commitment, are the basis of any organisation that wants to establish a resilient supply chain.

The major outcome of this study is a conceptual mapping of the CSFs. They can be put into four different domains, and work can be done to ascertain their effect on the supply chain's resilience. The literature review investigated SCRM and the issues arising in this field. Furthermore, PCA was performed on the CSFs, and the variance, their loading factors, and the commonality were explored in depth. This comprehensive study will be helpful for other researchers in this field and will serve as a starting point for additional research in the domain of CSFs for a resilient supply chain and their classifications, along with the gaps identified via the literature as well as other opportunities for research identified in this study.

Albeit most analysts would concur that supply chains are innately unsafe, one issue remains moderately neglected: a common point of view on the further development of supply chain flexibility to manage disruptions. This conceptual framework can be validated by a case study in any industrial sector and by verifying the robustness of the model.

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Characterising project management of lean initiatives in industrial companies — crossing perspectives based on case studies

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ABSTRACT
The paper mainly aims to characterise project management (PM) practices of industrial Lean initiatives by analysing and comparing three main topics: PM approaches, PM teams, and project alignment with the company's strategy. This research encompasses two exploratory industrial case studies with an extensive literature review. Key professionals were interviewed to obtain an in-depth vision of the field. The study results allowed characterising project management practices of industrial Lean initiatives in industrial companies based on the following dimensions: 1. Understand the needs; 2. Find a suitable team; 3. Use visual tools; 4. Apply a continuous improvement (CI) approach; 5. Identify KPIs for the context; 6. Get support from the top management. This work fills a gap related to studying the PM practices applied during the implementation of Lean initiatives, proposing a schematic representation of PM variables and actors in industrial Lean initiatives. Identifying the main variables and actors that industrial companies use to develop Lean initiatives can be insightful for Lean practitioners in the context of project management.

KEY WORDS
project management, project management characterisation, lean manufacturing, continuous improvement, multiple case studies

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Introduction

Doing more with less and respect for people is aligned with the Toyota practices mainly applied in the industry but spreading to many other types of organisations worldwide, under such designations as Lean Thinking (Jones & Womack, 2011), Toyota Way (Liker, 2004) or Shingo Model (Plenert, 2017). This way of thinking about production started in the 1950s with the development of the Toyota Production System and then gradually transferred to other companies from the end of the 1980s. Lean initiatives have been widely explored and applied in many business

Lima, R. M., Souza, I., Pereira, E., Belém, A. C., Pinto, C. M., Lazzaris, J., & Fonseca, P. (2023). Characterising project management of lean initiatives in industrial companies — crossing perspectives based on case studies. *Engineering Management in Production and Services, 15*(1), 57-72. doi: 10.2478/emj-2023-0005

areas, such as automotive, aerospace, healthcare, pharmaceutical, shipbuilding and public services (Ishak et al., 2018). Companies involved in such initiatives aim to overcome challenges, reduce waste and improve the performance of the production systems, delivering superior value to the client (Chiarini, 2015; Czabke et al., 2008; Romero et al., 2019). Bortolotti et al. (2015) and Bhamu and Sangwan (2014) described the following types of Lean initiatives developed in business environments: setup time reduction and Single Minute Exchange of Die (SMED); Just-in-Time (JIT) deliveries by suppliers; waste reduction; reorganisation of layout; improvement of the production flow, using Value Stream Mapping (VSM); pull systems and Kanban; standardised work and 5S; statistical process control; autonomous maintenance (TPM); multifunctional teams, employee involvement and small group problem solving; training employees; top management leadership for quality; supplier partnership; customer involvement; continuous improvement and kaizen; cellular manufacturing; Total Quality Management (TQM); production levelling (Heijunka); visual management, visual control (Andon) and Poke Yoke; automation and autonomation (Jidoka); and simulation.

Many studies were conducted, on the one hand, to examine the positive results of the Lean tools' applications (Ishak et al., 2018; Li et al., 2008; Middleton et al., 2007; Rosenbaum et al., 2014) and, on the other hand, to identify the challenges of its implementation (McLean et al., 2017), as well as subsequent success (Czabke et al., 2008). Notwithstanding the nature of the project per se and the methodology adopted, successful implementation of Lean requires the involvement and commitment of the employees, aligned with the company's strategy (Anholon & Sano, 2016; Backlund & Sundqvist, 2018).

Even though there are many works related to the success and difficulties of implementation of Lean, there is a lack of studies related to project management approaches of Lean initiatives in an industrial context. A previous work characterised eight main failure themes for continuous improvement Lean initiatives: "Motives & Expectations, Culture & Environment, Management Leadership, Implementation Approach, Training, Project Management, Employee Involvement Levels, and Feedback & Results" (McLean et al., 2017, p. 219). Challenges identified under these themes have not yet been completely overcome as this is mainly a contextual organisational issue, where different approaches may not have the same results in different initiatives. Considering research resources limitations and opportunities, this study team decided to focus on some of those themes, exploring the following questions: what are the main project management approaches applied in Lean initiatives? How are the project teams formed and managed? How is the top management aligned with the projects? Such questions are worthwhile to explore considering the importance of Lean to the performance improvement of business companies, highlighted and explored over the years in accountable contexts (Abideen & Mohamad, 2021; Gupta et al., 2020; Li et al., 2020; Lima et al., 2021; Miqueo et al., 2020; Ramya & Janani, 2020; Salentijn et al., 2021; Scheller et al., 2021; Singh et al., 2020; Wojtkowiak & Cyplik, 2020), and that project management is pointed out as being one of the main failure factors of continuous improvement initiatives (McLean et al., 2017).

Hence, this work aims to characterise project management practices when implementing Lean initiatives in industrial contexts. The research is based on the development of two exploratory case studies in two large industrial companies that have been systematically applying Lean principles and concepts through dedicated teams. Even though the type of project is an important factor in project management, the intention of this work is not focused on Lean initiatives and their results but, instead, is focused on project management applied to those initiatives, which is not being thoroughly addressed in previous articles. Moreover, these case studies will be cross related with a detailed analysis of the literature on Lean project management, contributing to a schematic model of approaches that have been used in industrial Lean contexts.

1. Literature review

The numerous benefits of implementing Lean, which nowadays represents the Toyota Production System (TPS) approach, have become globally acknowledged. Currently, standards and approaches are vastly applied beyond the automotive context (Ishak et al., 2018), thus, impelling the creation of innovative approaches within organisations (Singh et al., 2020).

From the point of view of project management, Lean approaches have been continuously expanding since the 1970s and, in both practice and research,

became known as Lean and Agile project management (Middleton & Joyce, 2012; Modranský et al., 2020; Tripp & Armstrong, 2018; Žužek et al., 2020).

This section presents a vast literature review focused on the project management approaches in the implementation of Lean initiatives, on project team management and, finally, on the alignment with the company's strategy.

1.1. Alignment with the company's strategy

In general, all companies would argue that there is an alignment between top management and projects being developed. But is that always true? Deming stated that "the problem is at the top. Management is the problem" (Dombrowski, Uwe & Mielke, 2014). Thus, according to these authors, behaviour change starts with the top management's commitment to project objectives.

How is the top management aligned with the projects?

The alignment should be noted at different organisational levels, and the understanding of project goals is crucial for achieving individual commitment to continuous improvement; therefore, there is a need for commitment and information transparency across all levels of the organisation (Holtskog, 2013). According to Ikuma et al. (2011), project promoters meet with upper-level management (president, vice president, and plant supervisor) to explain the project goals and the timeline for completion. Ishak et al. (2018) referred to the project approval dependency on top management and the importance of their support and cooperation during the project timeline.

Another example of the importance of top management alignment comes from the CEO of a Suzuki plant in Hungary. Knowing the importance of commitment as a key factor for booming change perception, the CEO walked around the workshop twice a week. This behaviour led to increased motivation in workers and became an integrator of Lean culture change (Elizondo et al., 2016). Holweg and Maylor (2018) approached the specific cases of major projects, referring that the main driver of projects is the top management. Major projects are problematic, with failure rates as high as 70 per cent, for the organisations that run them, their stakeholders and those involved in their delivery. The authors also referred that due to their inherent complexity, these projects could not rely solely on traditional project management approaches (Beecham et al., 2021; Towill & Christopher, 2002).

This allows for reinforcing the idea that projects that are more complex, transformative and vital to the organisation require more involvement in their management from the top leaders.

What are the main challenges of continuous improvement projects?

Productivity is one of the goals of continuous improvement projects, and it is all about the man–machine binomial (Jones & Womack, 2011). The machine is designed to respond to the man's desires, and the man needs to adapt to other introduced functions. The success of continuous improvement projects strongly needs interaction between humans and business goals (Elizondo et al., 2016). A well-nurtured balance between technical Lean aspects and activities relying on the relationship between the companies' persons has been identified as a fundamental cultural success factor of Lean initiatives (Bortolotti et al., 2015; Piwowar-Sulej & Podsiadły, 2022).

Holtskog (2013) referred to the relevance of counting with people to easily promote a change in the company — to incite a continuous improvement state of mind. This relates to the cultural aspects of organisational transformation, which must consider the commitment of employees to change, mostly when continuous improvement programmes are started and at different stages of such programmes (Jeunon, 2020). Otherwise, they may feel that they do not belong to a change process which could undermine the project goals. Holtskog (2013) described a way around the problem, which "was to take the standardised tools as guidelines and let the operators together make small changes to them". Hence, the condition of autonomous work is stimulated, also promoting team engagement, as well as the impassioned feeling of collaboration towards understandable goals. However, the challenges of continuous improvement projects do not change how people think. Significant and persistent challenges in continuous improvement projects include time pressure, sharing knowledge/findings, bureaucracy and time-consuming reporting/process routine, healthy work environment and communication (Backlund & Sundqvist, 2018).

1.2. Project management approaches/ tools

Organisations are continually faced with developing complex products, services and processes with

very short time-to-market combined with the need for cross-functional expertise (Tenera & Pinto, 2014). If the 1980s were about quality, and the 1990s were about globalisation, the 2000s are about velocity (Bennett et al., 2007; Moujib, 2007). The velocity requires management. According to Moujib (2007), Lean project management, as the application of Lean manufacturing principles to the project management process, intends to maximise value while minimising waste. Velocity is all about minimising waste in terms of management and maximising value by choosing the right team for the right project with the right methodologies as well (Anholon & Sano, 2016; Moujib, 2007). So, this section aims to identify some approaches, methodologies, frameworks, and tools applied in the literature to project management in developing Lean initiatives in industrial companies.

What are the main approaches to managing a project?

Despite the existence of several methodologies to manage a project or project phases, there are two main approaches — waterfall and agile — based on the interaction between the phases (Modranský, Jakabová, Hanák et al., 2020). In the waterfall approach, the project phases flow downwards, moving from one phase to another only once that phase has been successfully completed. The agile approach is characterised by frequent cyclic iterations between phases to promote improvements with high value and is mostly used to deliver results where the uncertainty is high (Cvetkovic et al., 2017).

The searched literature is not clear about the main management approaches. However, the agile approach is successfully applied to manufacturing, which reveals a constant need for adding value and time-to-market in a more complex and uncertain world (Hamerski et al., 2019; Modranský, Jakabová, Hanák et al., 2020).

How are projects initiated, monitored, and controlled?

Project monitoring is crucial to achieving expected results in terms of costs, time, and results. The results interfere with both costs and time, so it is important to have a clear view of desired project outputs and how to measure them, which may be translated to key project indicators (KPIs) (Stechert & Balzerkiewitz, 2020; Villazón et al., 2020). Chiarini (2015) referred to the application of a measuring process for three months after the operational change to evaluate the efficacy of the improvement. In the Indian construction industry (Kovvuri et al., 2016), the Last Planner System was used to manage a project, which was monitored through the Percent Planned Complete indicator.

Modranský et al. (2020) explained that in a project using the Scrum agile framework, the Scrum board is used, but it can be modified or adjusted to fit the needs of the project. They highlighted the initial idea where every team member had their colour stickers with tasks on the board. The tasks with an overall duration of two to four weeks are placed on the board, but each of these tasks is divided into smaller subtasks on a daily basis. Their Scrum board has six columns: task description, product backlog, to do, in progress, to check and done. This approach helps to facilitate the work and create flow, as referred to in other works (Hamerski et al., 2019; Ribeiro et al., 2019).

The Scrum framework proposes three roles: the Scrum master, the product owner, and the team members. The deliveries of features are performed incrementally in each sprint, i.e., in each cycle of development. The events to create such features are sprint planning, daily Scrum, sprint review and sprint retrospective. Additionally, the Scrum pillars are transparency, adaptation and inspection, which are in line with Lean thinking approaches (Hidalgo, 2019; Lei et al., 2017; Schwaber & Sutherland, 2020).

A common tool used for supporting project management initiation, and later for monitoring, is A3. It is a management process expressed in an A3 sheet of paper. In general, it is divided into two parts: the left side serves to identify the problem or challenge to be treated, and the right side contains possible countermeasures (Chen & Cox, 2012; McLean et al., 2017; Tenera & Pinto, 2014). This tool is commonly used in Lean initiatives for problem-solving and, consequently, for project initiation. It helps to define the reason for developing the project, including key measures of the problem, followed by possible solutions, actions and desired or expected key measures.

Another tool useful for problem-solving is the Ishikawa diagram, which is a visual diagram in a fishbone form that helps to find the root cause of the problem and work this cause by understanding situations related to man, machine, material, measurements, environment, and method. It aims to help the team to find the real causes of problems that affect the organisational processes of a company. That is, its purpose is to discover the factors that result in an unwanted situation in the organisation (Chiarini, 2015; McLean et al., 2017; Rodgers & Oppenheim, 2019).

1.3. Project team management

A project is an ecosystem that depends on project complexity, resources, and time. The project complexity is the result of an equation in which the project management approach, business area, bureaucracy, legal procedures, level of innovation, and human context are relevant variables (Gonzalez et al., 2011; Hamerski et al., 2019; Hidalgo, 2019; Schwaber & Sutherland, 2020).

Project teams are a fundamental part of project management, and there may be different approaches to team formation, development, management, and monitoring.

How are the project teams formed?

Modranský, Jakabová, Hanák et al. (2020) highlighted that in a lean project management environment, the team responsible for delivering the service or product must clearly understand the customers' requirements and translate those requirements into feasible projects. It follows the lean principles of value and value stream (Jones & Womack, 2011).

Even though it was not possible to find much information about team formation, it is possible to use information related to Scrum, as this approach follows Lean principles. Thus, according to the Scrum Guide developed by Schwaber and Sutherland (2020), an ideal team to perform an agile project must not have more than ten elements to ensure the quality of communication and avoid hierarchies. Such a team is composed of team members, a Scrum master, and a product owner who represents the customer. The Scrum master may be viewed as the project manager. The team focus must be the development of the expected result. Their experience demonstrated that a team should be "small enough to remain nimble and large enough to complete significant work" (Schwaber & Sutherland, 2020).

Do the teams manage their work autonomously?

Lean-agile teams are cross-functional, which means that members have all the skills necessary to create and deliver value at each step of work (Alahyari et al., 2019). This type of team is self-managing, which means they internally decide who does what, when, and how. "They are structured and empowered by the organisation to manage their work" (Schwaber & Sutherland, 2020). Thus, each member has a particular objective towards a common goal. Moreover, the entire team is accountable for creating valuable and useful increments at every step of their work.

In the software area where the agile approach is well spread, Middleton et al. (2007) stated that quality and productivity were achieved by breaking major parts of the product into stories made up of 3–5 features, which in turn were made up of 3–5 units of work.

Each unit of work would be developed for 2–5 days and have multiple work types within it. Additionally, teams could only work on a maximum of two features or feature-level integration at any one time. This also stopped teams from "cherry-picking features" they wanted to develop at the expense of the whole product. Modranský, Jakabová, Hanák et al. (2020) corroborates the division of the project into smaller tasks (sprints) and its distribution among the team members in which each sprint takes two months at maximum.

In traditional projects, it is usual to have a team leader who creates the team according to project necessities and guides the people through the deliverables. This team leader, which can be the project manager, helps to design the requirements, the milestones, the prioritisation, manage the risks and define the product or service quality. The teams are guided by his knowledge and leadership (Hamerski et al., 2019; Hidalgo, 2019; Modranský et al., 2020).

Lean and agile project teams require a high degree of flexibility and autonomy, which provide long-term success (Beecham et al., 2021). A clear objective of the company strategy is required to ensure that the different prospects of success, as the team structure, processes and culture, are aligned with strategy to deliver the best solution for the improvement, product or anything for the project goal (Rasnacis & Berzisa, 2017). The collaboration occurs on all lower levels, and additionally, an exchange of collaboration must take place between the team, for which shared visions, values and culture are essential as an in-depth corporate identity (Scholz et al., 2020).

2. Research methods

According to Freitas and Jabbour (2011), a case study is an empirical study that investigates a certain phenomenon, usually contemporary, within a real context of life. It is an in-depth analysis of one or more objects (cases) to allow a broad and detailed understanding of a phenomenon. Case studies can be classified according to their content and final objective, as exploratory, explanatory or descriptive, or according to the number of cases, as a single case or multiple cases (Voss et al., 2002). The main trend in

all types of case studies is that they try to clarify why a decision or set of decisions was made, how they were implemented and what results were achieved.

2.1. Process

For this study, some steps were followed: definition of the research topic; literature review; preparation of the research tool (interview protocol); selection of key informants at two companies in the study; data collection, analysis, and discussion; and conclusions. These methodological processes, represented in Fig. 1, followed the best practices of case studies presented by different authors (Freitas & Jabbour, 2011; Miguel, 2007).

As the main goal of this work is to analyse different approaches to project management in the implementation of Lean industrial projects, focusing on companies implementing continuous improvement projects, the research team decided to develop two exploratory case studies of industrial companies. The development of these case studies should be able to deepen the understanding of three main themes: project management characterisation of Lean industrial initiatives, project team management, and identification of the alignment of projects with the company's strategy. To define the research topic, besides defining the objective and the three main themes referred to above, the research team defined a set of research questions related to each topic (Table 1).

Answering these research questions required a deep literature review, followed by case studies with interviews of key informants in each company. The literature review phase aims to create the conceptual background for understanding and relating the studies. The result of the literature review made it possible to develop semi-structured interviews performed with people occupying different roles in the Lean structure at the companies where the case studies were developed.

The bibliographic search was done through an extensive investigation and selection of journal papers using Scopus, Web of Science and Google Scholar databases, focusing on project management and case studies of implementation of Lean initiatives. The main keywords used during the paper search were: "case study" or "project management" ("Lean manufacturing", "Lean thinking", "Lean Production", "Lean system", "Toyota production system" or "Lean management").

According to Cassell and Symon (2004), in semi-structured interviews, the researcher selects the main themes to be researched and defines the interview questions. Before the appointment sessions, a semi-structured interview protocol, as recommended by Saunders et al. (2009), was developed and validated by the research team. The questions were divided into four block questions, each relating to the research themes referred to in Table 1. The sessions were recorded during virtual meetings due to the pandemic restrictions.

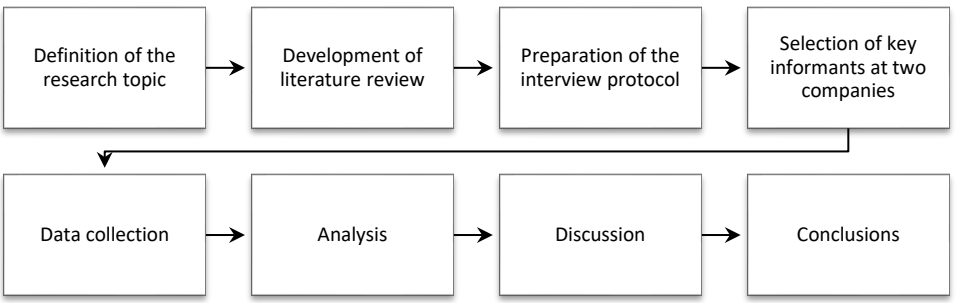

Fig. 1. Research process flow chart

Tab. 1. Research questions

Research themes	Research questions
Project management approaches/tools	What are the main approaches to managing a project? How are the projects monitored and controlled?
Project team management	How are the project teams formed? Do the teams manage their work autonomously?
Alignment with the company's strategy	How is the top management aligned with the projects? What are the main challenges of continuous improvement projects?

2.2. Context

Two industrial case studies were developed to analyse the project management approaches of continuous improvement Lean initiatives in different companies. The study was developed in two large companies, one from Portugal and the other from Brazil. Following a recommendation by the European Commission for micro, small and medium-sized enterprises (SMEs), the Portuguese law (Certificação de PME Online, 2007) defines SMEs as companies with less than 250 employees, with an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet not exceeding EUR 43 million. Thus, large companies are the ones not included in this definition. A company in Brazil is classified as large if the annual income is higher than BRL 300 million (BNDES, 2021), i.e., more than EUR 48.5 million (converted on 16 August 2021), or has more than 500 employees (CONUBE, 2018).

The company identified as Company 1 is located in the southeastern region of Brazil, operates in the field of iron ore exploration and has approx. 4100 employees. This company has an extensive background in Lean, from exploring machine maintenance for waste reduction to developments on production variability improvement to reduce costs. They have teams dedicated to the development of Lean initiatives and the implementation of continuous improvement. Even though the company has been applying Lean concepts for a while, the formal Lean initiative implementation first occurred in 2014 with the sponsorship of the corporate director. Then, the knowledge generated by the pilot project was replicated in other areas. Nowadays, this approach to Lean initiatives focuses on working at the operational level, raising awareness of basic concepts, and transforming the way of thinking: seeing what does not add value to the process, i.e., waste, and then improving processes.

Company 2 is in the north of Portugal, operates in the production of components for the automotive industry, and the number of employees is about 4500 people. They have a department dedicated to the development of Lean initiatives. The continuous improvement process follows a roadmap pre-established every year and aligned with the company strategy. Their Lean specialists work disseminating Lean thinking in the whole company, applying the methods and tools through the line production to the supply chain. The implementation of Lean initiatives started in 2002 with the main objective of fulfilling customer orders and avoiding waste from the product development phase to its delivery. Currently, the strategy is to make small improvement sprints until reaching the goal of 2022 to have the production plan levelling implemented throughout the factory. The focus is on working at the base to consolidate knowledge and then implement level plans, production controlling tools and a full pull system.

3. Research results

Although the companies belong to different business areas, a similarity is observed in the approaches used in their continuous improvement projects. As aforementioned before (Chapter 2), qualitative data were collected through semi-structured interviews with the key informants of both companies. We have used a general inductive approach (Thomas, 2006) to provide assumptions and present findings based on summaries of the data collected through interviews. Hence, endowing relevant links between the findings and the proposed research. The results obtained are summarised in Table 2.

The summary of the data presented in Table 2 allows for establishing a parallel between the companies regarding the description of the applied methods, tools and frameworks. The use of tools, such as A3, was observed, as well as methods, such as PDCA and Kanban, and roles, such as project manager and value stream manager. While most of the methods and tools may be associated with Lean approaches, there is also the application of the waterfall method in some cases. Nevertheless, in the cases where this approach

Tab. 2. Characterisation of project management approaches in both case studies

Topic	Company 1	Company 2
Project management approaches/tools	Scrum; A3; Waterfall; QCC (Quality Control Circles); PDCA.	A3; Waterfall; KPIs; PDCA; Small cycles
Project team management	Multidisciplinary teams; Hierarchical; Autonomous for task development	Multidisciplinary teams; Hierarchical; Autonomous for task development
Alignment with the company's strategy	Weekly report; Monthly meeting of alignment	Quarterly meetings of alignment; Steering Committees to share experiences and promote benchmarking

is used, it is incorporated in hybrid approaches for a general overview of the main phases being the operational management done using agile approaches.

Moreover, the operational teams defined the KPIs that best reflected their performance; hence those can be monitored and improved throughout the project. Haug (2011) maintained that the best way to directly involve employees in improvement projects is through the creation of work teams by sharing common goals and performance targets. Scrum approaches were also implemented in both companies as an agile, flexible, adaptive, and iterative way to manage Lean initiatives.

This framework defends a continuous planning process based on self-organised and empowered teams that work together to achieve a common goal (Sutherland & Sutherland, 2014). Both companies reported using multidisciplinary autonomous teams and continuous feedback to some extent.

The main concepts of the Lean philosophy are applied in projects of both companies, aiming to reduce waste, obtain better results and deliver value to their clients. Authors Hussain (2019) and Ishak et al. (2018) reported similar objectives and proved the benefits of applying lean tools (5S, VSM) and principles to save energy and damage to the environment or to maximise profits and minimise costs, respectively.

There is the objective of aligning the Lean implementation projects in this case study with the company strategy, which aims to increase the competitiveness of the company in its business market. Thus, it is important to highlight that these projects are developed looking for real, measurable outcomes, i.e., improvements in the production system, looking for a positive impact on the business, employees' life, top management results and even the local environment where the company is established.

3.1. Alignment with the company's strategy

Company 1 top management does not define the projects to be executed; instead, the employees composing the project team are motivated to align kaizen activities with the company's strategic goals. A kaizen board is available at the Gemba so that everyone may follow the current state of the projects and perform the updates. During these updates, the team checks the performed activities and looks for tasks that need to be concluded. Once a task is considered done, it opens a space for a new task that can be a new necessity of the project or a previously planned task.

"(...) we brought the challenge to the team to try to understand what can be done through Lean to reduce waste and improve the routine for increased productivity. Even kaizens were designed in this direction. To reach this capacity, I need to spend half an hour on this activity; what kaizen can I perform in this regard? So, we were able to deploy a goal there at the activity level." C1

The outcomes of Company 1 projects may vary, but after the QCC and the simple see-and-act to discover the needs of some departments or some production lines, the continuous improvement project begins. As an example, using the PDCA methodology, the company could reduce the time expended in a process, reduce the number of defective parts, and increase productivity using the same number of resources. Other outcomes from these projects are the qualification of team members through training. To deal with the complexity regarding the kind of projects, people receive training in 5S and seven wastes, which spread the knowledge and competencies of people.

In Company 2, the projects come from the company's strategy that is designed and updated every year according to business goals, market change and customer requirements. Considering that information, the lean department looks for a possibility to improve all their value streams and starts developing projects. The projects' outcomes may be to establish a pull system in a specific department, stabilise the performance indicators, create standards for JIT, implement the 5S philosophy in a particular area, or even improve the short cycles of PDCA regarding specific projects. Thus, Company 2 has an extensive engagement of the top management, promoting steering committees for benchmarking between departments and other production plants. Additionally, there are monthly events to acknowledge team projects which achieved higher recognised contributions for the objectives of the company. Company 1 promotes a different kind of engagement, delegating the alignment with the strategy to the project teams. The responsibility to promote this alignment is one of the team's commitments, promoting employee understanding and continuously looking for strategic goals.

At the interview in Company 2, the Lean Department Coordinator explained that their projects are simple and tangible, with focused KPIs and very clear objectives. Ideally, they should generate only one

standard, always considering the Value Stream vision strategy. The goal is to have short project development cycles to deliver incremental results. When a standard is concluded and stabilised, the team may move to the next improvement. For that, projects must be focused, with the indicators well defined and generating short and fast PDCA cycles. The focus is continuous improvement, i.e., to obtain incremental improvements until reaching an overall higher goal. The next excerpt reflects this approach.

"In the last years, we have shown fantastic results in terms of factory indicators, in terms of gains, and productivity increases. (...) So, it (projects) can be derived from the company's strategy and business requirements, or it can be derived from the Value Stream and the vision we have for this Value Stream. So, imagine we have a vision for three years from now to have a pull system implemented, and we will create projects so that this reality can happen within the stipulated period. So, we look at the Value Stream and say: three years from now, I want to have the pull system on this product. So, let's create projects and run PDCA cycles so that this can be a reality on the date that was predicted". C2

A common practice at Company 1 is to demonstrate strategy alignment with continuous improvement projects. During the semester of corporate kaizen conventions, each executive area is represented by one team. The best one is recognised and awarded. Additionally, each month, the best projects in the following categories are chosen: the number of kaizens identified and executed, health and safety, and administrative.

At the interview, the Lean Department Coordinator of Company 1 said that projects were fully supported by senior management and considered part of the company's policies. Moreover, the local manager was fully involved with the projects and participated in kaizens presentations and recognition meetings. Each project had its indicators related to working conditions, safety, and standardisation. To assess the Lean evolution in the area, the number of kaizens (continuous improvement projects) executed, the number of kaizens per employee and the number of replicated kaizens were monitored.

"Currently, top management is focused on stability and has the minimum deviations from the standard, with the equipment in adequate conditions. (…) Even in the management's annual strategic planning, we started to focus on the customer and what the customer expects from our management in terms of service, quality, and cost. Top management promotes, as recognition, every month what we call the vote of the people, where in each supervision, the team votes on the best kaizens. Those elected go to a leadership committee, where another vote is taken with predefined criteria. From there come the kaizen's highlights of the month in management, which are awarded prominence in health and safety, administration, the number of kaizens identified and executed (…), and at the end of the year, the best project is elected at the kaizen corporate conference". C1

In the Company 2 interview, the Lean Department Coordinator narrated that the plant production top management was closely linked to the development of projects. Biweekly, a Value Stream Manager was recognised with a symbolic prize, but the recognition process was very much appreciated. Additionally, the teams participated in weekly recognition activities and biweekly project presentations. This involvement helped to motivate and engage the team that worked on continuous improvement because they felt that their work was valuable to the company. Additionally, there were steering committees, which ensured that projects were done according to the Lean principles. There were also meetings involving other company plants, where team leaders presented best practices, project results and main difficulties. In these meetings, the plant was visited by top management to acknowledge the work.

Another evidence of this strategic involvement is that the system used to run the projects is available to the top management. They can follow what is being developed and in what phase the project is, and every month, a general meeting is called between the project team, value stream managers, project owners and top management to keep projects aligned with the company's strategy. The projects use indicators related to the following dimensions as a starting point: delivery of the finished product, the level of stock, the quality of the product, and the cost.

"In the case of our production plant, which I know best, the top management is fundamentally linked to the development of improvement projects. They participate in all weekly activities that we have, both in recognition of good projects and in the common presentation of projects. We have weekly activities with presentations of completed projects, and project development and management representatives are always present in these activities. So, they have perfect knowledge of projects created, validate them, validate the development process and validate the closure of the projects and even the recognition of a good project. They are present, and they deliver the

prizes we deliver for the different projects that have the best development." Company 2 Lean Department Coordinator.

Regarding the testimony of the companies, acknowledgement of the work done by the project teams is very important, and both companies have implemented meetings to discuss the best practices of projects, contributing in this way to promote benchmarking, improve processes, and elevate employee motivation. It is an opportunity to share knowledge with other subsidiaries of the company and to be recognised as an expert in the area.

3.2. Project management approaches

Projects can be managed using different tools and will always include the development of documentation with lessons learned for the next projects. In the case of Company 2, for example, project management is organised using an internal tool to manage continuous improvement. The developed tool even includes the PDCA cycle. The tool establishes the project flow in a visual form using A3, enabling the PDCA application and allowing for the application of different lean tools, such as the Ishikawa diagram, 5W2H, 5 Whys, and Kanban boards.

Company 1 uses agile approaches for project management, including elements of Scrum. These approaches are used because they help increase the speed and analyse the performance of projects. The company highlights that they are not tied to a model and that the concepts are applied practically, even without naming them.

They are not applied to all projects, as the company started the framework application some time ago to perform experimentations within agility, and after that, if the entire framework fits well, to expand it to other projects.

"Since last year (2019), we have been bringing agile methods to help us in project management. For example, in some projects, we started using Scrum to augment speed. We put the board with the post-it in the area (factory circulation environment), showing what we must deliver for that week and what we need to do to trigger the sprints. Now we are starting the phase of designing strategic/project, A3 and the proposal is that these A3 transform themselves visually through a Scrum in the workshops". C1

It is possible to highlight that both Companies use visual management approaches to follow the progress of projects. Company 1 uses A3 panels in the department, which allows for monitoring the stages of the project until that moment. Company 2 uses A3 in an online tool developed internally where they can perform the follow-up of each project. The focus of Company 1 with A3 panels is to share the developed kaizens and make it visible to all team projects to collect insights about the improvement. The focus of Company 2 is unifying all information in the same tool, to which all people involved in the project process have access. Both companies have a standard way of representing the project, which contains all the information about the project.

According to what was said by the Lean Department Coordinator of Company 1, there is no strict definition of the project life cycle. For example, they are defined as problems and challenges that arise, which are observed as improvement opportunities by the team. Because they call these projects kaizens, it is a way of promoting improvement. Those kaizens (projects) may emerge from:

- Routine problems: they deal with the impacts of daily delivery. Indicated by employees in visual management charts in the area.
- Management strategic goals: which are deployed and managed by A3. From these A3s, several kaizens appear.

The dimension and complexity of the projects may vary according to the project type. The Lean Department Coordinator argued that the projects were designed to have short cycles but were aligned with the value stream goal. Integrating small projects would contribute to a great impact at the end of a year, for example. The duration of the projects is variable and depends on the complexity of the project; there is no predefined duration. The team's dimension may also vary according to project complexity and needs but is between four to ten persons in a multidisciplinary team.

"(...) and with the multidisciplinary of the team and their involvement (performance as a team), the number of kaizens that were performed by the working groups grew as they began to understand the concept. In the beginning, it was very kaizen focused on the area organisation, normal and abnormal conditions, and approach to resource". C1

Similar to Company 1, the dimension of lean initiatives developed by Company 2 may vary according to complexity and project type. The Lean Department Coordinator argued that the projects are designed to reach the goal of the Value Stream vision, which is defined to be achieved in three to five years. Then, it is fragmented into small projects with short cycles of development running a PDCA, and the

project team may vary between three to ten members. Nevertheless, the company wants projects to reach the stabilisation phase in three months, one month for planning and creating a standard and two months for stabilisation.

All projects are always developed using the improvement cycle (PDCA) method, and monitoring is performed by the A3 tool. They also use other supporting tools, such as a digital system that was developed for project management and execution (all project information is recorded in the tool according to the PDCA). This tool assists owners and value stream managers in monitoring projects. The project manager or product owners have an approach to defining projects that are linked to business requirements, the company's strategy and customer needs. Aligned with this vision, a quarterly meeting is held with the Value Stream Managers, the department heads, and the production plant direction, where projects are defined based on strategies or problems arising from the line.

"We must be realistic in continuous improvement. I cannot reach the specialist for the screwing machine and say that I want him to solve everything in three months and that I want zero defects in the screwing machines; it is not possible. We cannot set goals unattainable because we are going to discourage the team from the beginning. So, we must give simple projects with very clear objectives that are tangible; if they are not tangible, we will lose the project. (…) for that, we must work on project derivation very focused on a very straight result and small steps for continuous improvement, very short and fast PDCA cycles; this is step by step". C2

Project monitoring is performed frequently by the project owner using internal tools. The updates are performed weekly to see what tasks were concluded and which require to be developed. If someone has a problem to solve or an issue with task completion, the project owner provides the needed support. Included in this monitoring process, the team undertakes related activities, i.e., checks for the predefined action plans, feeds performance indicators, puts new tasks in A3, or advances to the next step of PDCA.

3.3. Project team management

During the interview at Company 1, the Lean Department Coordinator explained that the project's complexity was variable, ranging from problems treated as see-and-act to more complex problems treated in groups of specialists or QCC (Quality Control Circles) using the PDCA. Romero et al. (2019) explained QCCs as small groups of workers, collaborating in a project context or not and periodically meeting to discuss production, quality, and issues related to the production system.

"There was a project where we delivered training related to 5S and seven wastes. Then we delivered a problem-solving training, using the A3 for problem-solving and QCC. Initially, we have done this training with the leadership, as they are the motivators to give the guidelines to the operational team. We created a problem management routine and visual management tools in the production area, using post-its and flip chart sheets, so the team could easily identify problems and manage the projects". C1

During the development of Company 1 projects, the project team may have no autonomy over decisions, needing to involve other areas or higher hierarchical levels. This happens in projects with a hierarchical organisation, which may cause some delays. Hamerski et al. (2019) argued that providing autonomy for the teams may contribute to avoiding the waste of "asking for permission" to solve an issue. The Head of the Lean System also argued that the team members had the autonomy to develop their daily work. The kaizens can be developed individually or in groups; it depends on the project approach and needs. But the project team manages their work to solve issues that appear in the daily routine.

"We have three fundamental roles in project teams. First, the Lean Department Coordinator. Second, the lean specialist will help establish the Lean concepts, give the pace of implementation, and take (people) out of their comfort zone. Third, the area team leader, who is the person leading the project, creates a bridge between the lean specialist and the good process practices." C1

According to the current context, the team allocated to a project is not full-time dedicated, and the level of dedication will vary depending on the project's characteristics. The two most important roles considered by Company 1 to manage the projects successfully are the Lean system specialist and the team leader. The Lean system specialist helps to establish the concepts in the area and gives the pace of implementation. All supervisors have access to a Lean system specialist. The team leader will make the bridge between the Lean system specialist and the production practice. He/she is on the factory floor (Gemba) supporting other employees.

Regarding project team management at Company 2, the team may be fully dedicated to the project,

which varies depending on specific phases or the project's urgency. In some projects, it is determined a priori how much time each element will dedicate. In other projects, the owner manages the required workload according to the activities and availability of the team members. The product owner may be chosen according to the problem that needs to be addressed and is chosen by the Value Stream Manager. This product owner should have project management skills and technical knowledge related to the problem, which is helpful for developing the project. He/she is also responsible for managing the difficulties and for choosing the team members, which may vary throughout the project and the phase of work. Regular meetings are performed by the team to monitor the development of each stage of the project.

Company 2 referred to one example where a project was carried out by a team working fully autonomously with no need to explain what needed to be done or to coach them, but that is very uncommon. That team could identify problems and propose projects by themselves, and they worked very well.

"The Value Stream Manager keeps the project and chooses an owner according to the problem or type of project, and these people must have know-how both in project management and in the problem itself. (We will look for) Someone who is an expert and who knows how to manage a project. The team elements can come and go, depending on the development of the problem. (...) Just in very specific cases, we had an autonomous team, but it is not common. It happens when the team members know each other for a long time and have total expertise in the work". C2.

4. Discussion of the results

The analysed case studies allowed for confirming a significant number of concepts, ideas, approaches, and methods reported by the literature regarding the characterisation of project management in industrial Lean initiatives (Chiarini, 2015; Czabke et al., 2008; Romero et al., 2019). As referred by Bortolotti et al. (2015), the developed types of projects are related to the identification of needs for the improvement of internal processes or customer service. The identification of these needs may come from continuous improvement of formal processes and departments or the opportunities for the reduction of wastes identified by the employees. Thus, measurements based on predefined KPIs are a strong source for this identification. But selecting the next project is a result of an alignment between needs and strategic goals, which may also be a source for those needs. In a continuum, as represented in Fig. 2, "needs" originate initiatives, which are developed by a project team using visual management and project KPIs for monitoring the state of the project. Previous sections described the industrial case study details regarding the specific types of initiatives, how the teams are formed and managed, the visual tools and the project KPIs.

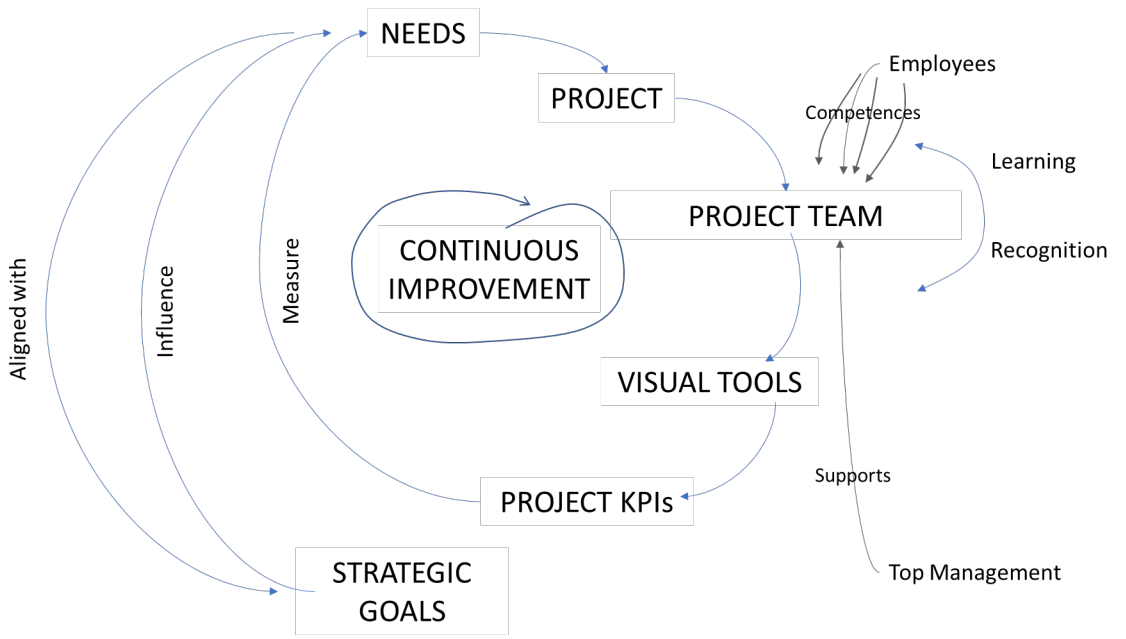

Fig. 2. Schematic representation of project management in industrial Lean initiatives

A distinct feature of these case studies is a strong notion that people are at the centre of the development of initiatives, and as Lean principles' advocates, both companies intentionally created ways to recognise (Chiarini & Brunetti, 2019) and take the most from those project teams (Tortorella et al., 2021). This is one of the most explicit results of these studies, which showed that Lean initiatives need small multidisciplinary project teams and that these teams need to continuously evolve and help other teams to evolve. Support and recognition by top management are also in place for both companies, with small awards, presentations, and the identification of successful teams each month.

Finally, based on the characterisation that was developed in this work, it is possible to present a set of recommendations for the management of industrial Lean initiatives:

- Understand the needs: needs may be set by strategic goals or must be aligned with those strategic goals. This may be put in place by more structured ways of relating different levels of KPIs or may result from bottom-up with employees understanding and establishing the alignment.
- Find a suitable team: small multidisciplinary teams should be put in place, mixing technical, Lean and project management competences. In most cases, these teams are hierarchical, with explicit leadership but with strong individual autonomy for developing the tasks.
- Use visual tools: the main tools used by the case studies companies are the A3 and Kanban boards. These tools may be implemented physically or with electronic tools, allowing for the facilitation of daily work, assignment of tasks, monitoring, communication, and transparency.
- Apply a continuous improvement (CI) approach: both companies referred to the PDCA methodology, which is a well-known tool for CI. Another tool to promote continuous improvement is DMAIC, as was exposed in the literature review section.
- Identify KPIs for your context: seeking effective opportunities for improvement needs to be based on relevant measurement, which may be related to customer satisfaction, internal processes improvement or the CI projects themselves, associated with the number of improvement proposals.
- Get support from top management: top management must be supporting Lean initiatives, personally monitoring some of the projects and creating recognition instruments.

Conclusions

This paper presented a parallel between the literature and two industrial case studies. Using the case studies developed in two large industrial companies, one in Brazil and another in Portugal, this work contributed to a better understanding of the best practices of lean project management that are currently being developed. The exposure to these practical contexts, showing the Lean application, enlarges the knowledge of Lean and contributes to further research and practice.

The case studies revealed the following points of convergence between the companies:

- The Lean initiatives are strongly supported by top managers.
- Teams have levels of autonomy that contribute to empowering them, which, together with the recognition instruments, contribute to motivation and share best practices.
- Visual management with A3 and Kanban boards and KPIs monitoring, geared by PDCA methodology, support the project management approaches.
- Both companies recognise the best practices with rewards.

This article is innovative by pointing to project management approaches in the context of Lean initiatives. This is supported by the identification of types of projects, project management, project teams and alignment with the company's strategies. Additionally, schemes and recommendations based on case studies and the literature may support new studies and their application to other companies striving to develop Lean initiatives. This will support a company's strategy as guidance to identify needs, start a project, develop a team, and manage the project using visual tools and KPIs.

This work suffers from the limitations imposed by case studies, which may not be generalised. Nevertheless, the deep and vast literature review and two case studies contributed to reducing this limitation and showed that different companies in different countries have comparable approaches. Nevertheless, these are both large companies and making these ideas applicable to small and medium companies will need deeper studies and identification of main constraints. Although the vision of the interviewees,

namely, Lean System Heads and Lean Department Coordinators, is quite in-depth, future work could provide different perspectives from employees involved in the projects. Thus, an opportunity for future research is the application of questionnaires or semi-structured interviews at different levels of the organisations and in a larger number of organisations.

Another point that is important to highlight in this study as a reflection is the current pandemic times. The COVID-19 pandemic forced many businesses to take a pause and reflect on the possibilities of new unthinkable challenges. Although production improvement projects may be disregarded in such struggling times, it is also in such times that a company may benefit from the opportunity that Lean and continuous improvement projects bring. A continuous improvement mindset looks for integrated improvements in a flexible and agile approach, capable of dealing with fast needed changes and adaptations. This is done by listening to people truly from the Gemba up to top management, providing training if needed and making the information and communication transparent. Thus, companies with such mindsets are better prepared for the needed changes and adaptations.

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Impact of cash flow variation on project performance: contractors' perspective

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ABSTRACT
This study aims to determine the impact of cash flow variation in Jordanian construction projects from contractors' perspective and its relationship with project performance. An online questionnaire was developed and distributed to a selective sample. The respondents were project managers from contracting companies working in Jordan, around 340 construction companies. The sample frame was a form of non-probability sampling of 181 project managers. The collected data were analysed using the Statistical Package of the Social Sciences (SPSS) version 25. The study results showed a positive statistically significant effect at the significance level ($\alpha \leq 0.05$) of cash flow variation on project performance in Jordanian construction projects. In addition, respondents indicated a high level of agreement on the impact of cash flow variation on projects' performance, with a mean of 4.01 and a standard deviation of .546. However, on the project performance dimensions' level, Quality came first, with a mean of 4.11 and at a high level, followed by Safety, with a mean of 4.01 and at a high level, while Final Cost ranked third with a mean of 3.96 and at a high level. Finally, Project Final Duration ranked fourth with a mean of 3.95. The researchers recommended the necessity of more efforts for a better understanding of the importance of cash flow by contractors to schedule project activities correctly and efficiently to maintain a steady state of the project cash flow.

KEY WORDS
cash flow, project performance, Jordan, construction, cash variation, contractors, quality

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Introduction

The construction industry has direct and oblique links with different industries, extending its effect on economic growth and prosperity past its direct contribution to construction activities (Iyer et al., 2008). The concepts of "success" and "failure" are relative and extraordinarily subjective (Parfitt & Sanvido, 1993). Each stakeholder has their own personal definition of success and failure, which can also differ within the same project as well as from one project to another. One participant's success can be another's failure. Thus, concluding or deciding whether a con-

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struction project is a success or a failure becomes an extremely complicated procedure (Sinesilassie et al., 2017). In general, when a construction project is finished on schedule, without cost overruns, and according to specifications, it is considered a success; these three criteria have been employed by a number of academics to assess project performance (Koelmans, 2004). Cash flow is the backbone of the construction industry, and it is often regarded as the most valuable resource available to a company (Al-Joburi et al., 2012). The movement of money in and out of a company is referred to as cash flow. Cash flow is crucial since it is necessary to satisfy obligations when they are due. A company's operational capital must be adequate to pay its vendors, customers, subcontractors, and employees (Ali et al., 2018).

In this study, four dimensions were selected to measure projects' performance: Time, Quality, Safety, and Cost. These dimensions were chosen as the most influential dimensions in the performance of construction projects according to previous studies (Djatmiko, 2017; Michael, 2018; Mahmoud et al., 2020). In addition, these dimensions are directly and significantly related to cash flow, as any change in cash flow will directly affect these dimensions. So, it is necessary to study these dimensions and reveal the cash flow variation impact on them.

The choice of these dimensions came due to their importance and necessity for the success of any project, as the level of performance of construction projects is greatly affected by the time required to complete the project compared to the cost allocated for this project, with the need to maintain safety for all project workers, in addition to the importance of producing results at a high degree of quality.

All of this is what motivated the researchers to choose these dimensions and study them carefully to determine their relationship with the cash flow and their impact on the performance of construction projects.

Previous studies (Djatmiko, 2017; Sharifi and Bagherpour, 2016; Zayed and Liu, 2014; Al-Joburi et al., 2012) have indicated the importance of examining the impact of cash flow on project performance, as this has an impact on the project ability to continue and to achieve its goals, as exploring the suitable cash flow for a construction project with regard to project needs will help project managers achieve the desires of users and meet their demands efficiently. Despite the multiplicity of these studies, the effect of cash flow variation on project performance still needs more study and examination (Mahmoud et al., 2021; Koopman & Cumberlege, 2021; Al-Subaie et al., 2021).

Also, there is a rarity of studies that deal with the effect of cash flow variation on project performance, especially in Jordanian construction projects, and accordingly, the subject of the study was chosen to reveal the effect of cash flow variation on Jordanian construction project performance from contractors' perspectives. Therefore, the contribution of this study to the body of knowledge is to determine the cash flow variation, the factors that affect it during the construction project, and its effect on the project performance, especially on the project's final duration, quality, safety, and final cost. Since few studies have been found on this subject in Jordan, this study will try to fill the gap in the literature about these concepts.

Furthermore, the significance of this research arises from the fact that it will attempt to investigate the causes and effects of cash flow variance in Jordanian construction projects from contractors' perspective, as well as the relationship between cash flow and project performance. Examining this issue may give contractors the methods they need to manage cash flow variability and, as a result, complete a successful construction project.

To guide this research and achieve the goals mentioned above, it is important to set the main questions which must be answered during and after the research:

- What are the causes of cash flow variation in Jordanian construction projects from the perspectives of contractors?
- What is the impact of cash flow variation on construction projects' performance in terms of the project's final duration, quality, safety and final cost?

1. Research background

Construction project management concerns the context and attributes of projects to ensure that events adhere to plans and standards. Nonetheless, performance dissatisfaction is a widespread issue in the construction industry. A typical project may face a number of challenges that impair its performance in areas such as poor productivity (Makulwasaatudom et al., 2003). Other construction difficulties stem from the chronic twin issues of time and cost overruns. Despite the creation of new alternatives and less combative contractual structures, Yisa and Edwards

(2002) agree that project time and expense overruns continue to plague the business, resulting in client discontent.

For analysing management performance and formulating business strategies, performance evaluation is an important instrument. The desire to increase performance in the construction business has become a hot topic all around the world. For example, the UK construction industry launched a number of investigations in this regard. Rework of defects contributes significantly to cost performance issues in the US construction industry, accounting for an average of 5 % of total construction costs (Tunji et al., 2016).

In developing countries, a lack of necessary resources and structures to handle performance difficulties exacerbates the problem. According to studies, time overruns cause failures in 40 per cent of building projects in India. Many challenges plague Ghana's construction business, including contract administration, complicated and time-consuming payment procedures, and late payments (Tunji-Olayeni et al., 2016).

The most critical stage in performance improvement is a diagnosis, not intervention, because an accurate diagnosis of performance demands and shortcomings is what leads to improvement success (Ankrah & Proverbs, 2005). It is impossible to increase performance unless it is measured (evaluated).

Performance measurement is the process of determining how successful organisations or individuals have been in reaching their set goals. It is a mechanism for identifying sources of unnecessary waste so that the company can focus its resources where they are most needed. It shows the state of play and, more importantly, the direction of further developments. Also, measurement can promote steady progress toward specified targets while also identifying inadequacies or stagnation. Measurement of performance is important because it indicates the status and direction of a project (Egwunatum, 2017). Performance measurement's purpose is to offer quick and accurate feedback on operational efficiency and effectiveness and to keep the focus on continual development (Bassioni, 2004).

Performance measures are crucial criteria of an institution aiding in determining whether the practices of a method or the results of the project achieve the targeted objectives. They could be used to translate an organisation's strategy into a group of aims and goals, and the results achieved through the measures represent the strategy's achievement. Performance measures reflect the institution's priority elements and how workers must act in order to achieve the best possible results (Neely et al., 2002).

It is widely agreed that, at the very least, project performance measures rely on time, cost, and quality. The three aspects of project performance are known as the iron triangle. A number of criteria are used to evaluate a project, including sticking to the budget and timeline, the quality of the work, stakeholder satisfaction, technology transfer, safety, and health (Tarawneh et al., 2020; Akpituren, 2016).

Similarly, Chan and Tam (2000) found that project performance is measured using a variety of important factors such as health and safety, environmental performance, user expectation/satisfaction, actor satisfaction, and economic value. As a result, they established six elements to examine when evaluating project performance: cost, time, quality, customer satisfaction, health and safety, and functionality.

Clients, users, stakeholders, and the general public often evaluate project performance from a macro viewpoint, with completion time appearing to be the foremost criterion for project success (Lim & Mohamed, 2000). According to Salter and Torbett (2003) and Odeh and Battaineh (2002), time variance is one of the methodologies for factor to evaluate a construction project's performance. The issue of time could alert project managers to the fact that the project was not progressing as planned (Tarawneh et al., 2020). Furthermore, according to the Latham Report from 1994, one of the most important objectives of construction sector clients is to ensure timely project delivery. Construction time refers to the time it takes from the commencement of site work to the completion and handover of a building to the client. Prior to the start of construction, the construction time for a building is usually defined. Construction time can be estimated using information from the client's brief or accessible project data by the construction planner.

The degrees to which general conditions facilitate the execution of a project without serious accidents or injuries are defined as health and safety. Safety is mostly measured during the construction phase, as this is when the majority of accidents occur. The construction sector is regarded as one of the most hazardous industries in the world. Every year, thousands of people are killed or injured in workplace accidents. Construction workers have three times the risk of dying and two times the risk of being wounded than workers in other industries (Sousa & Teixeira, 2004). According to Sarireh and Tarawneh (2014),

building accidents are caused by violations of safety standards and regulations. Other factors include a lack of training programmes, a lack of safety coordination, lectures, and poor building circumstances. Other causes of accidents were deemed to be poor equipment quality and the absence of testing by a specialised safety team on the project site.

In the construction industry, quality is defined as the total of traits that a product or service must have to meet a specific demand or fitness for purpose. To put it another way, quality in the construction sector is determined by the ability to achieve predetermined requirements. A characteristic is any standard or quality that specifies the nature of those items, processes, or services that are initially determined by the client, whereas requirements are the established characteristics of a product, process, or service as described in the contractual agreement. To complete a project that meets the owner's quality requirements, all project participants must have a thorough awareness of the owner's expectations, factor them into the contract price and other contract agreements as much as possible, and commit to carrying them out in good faith (Ganaway, 2006).

Cost describes the extent to which general conditions support the completion of a project within the anticipated budget. Cost variance is the most common method for evaluating design performance, according to Salter and Torbett (2003). It includes any costs paid as a consequence of revisions, modifications made during construction, and expenditures incurred as a result of legal claims, such as litigation and arbitration, in addition to the tender value. It can be calculated in terms of unit cost, net variance over final cost, and other variables (Chan & Tam, 2000).

Cost variation is a critical metric for assessing project performance since it tells whether the project is on budget or not. In Japan's construction business, cost variance was utilised by Andi and Minato (2003) to quantify project performance caused by poor design. Similarly, Georgy et al. (2005) proposed using cost as a metric for evaluating engineering project performance; they defined cost variance is defined as the difference between a project's actual and projected costs.

The most difficult and crucial challenge facing contractors is obtaining sufficient cash flow at all stages of construction project implementation. Sufficient cash flow is required to meet three goals: paying for overheads, labour, and material costs; completing building activities on time; and reducing financial liabilities. In other words, effective management of cash flow is critical to running a profitable construction company. Successful contractors avoid carrying out work that exceeds available cash or credit at any point throughout the project, regardless of schedule requirements. In other words, contractors want to ensure that they have enough cash on hand at all times. Furthermore, the lack of appropriate construction finance planning can result in considerable cost and time increases, as well as the financial failure of the construction project (Michael, 2018).

Cash flow is the lifeblood of the construction business, and cash is usually regarded as the most valuable of a construction firm's assets (Hyung et al., 2005, Arditi & Polat, 2010). Cui et al. (2010) discussed project cash flow management solutions using a systems analysis methodology. In view of these perspectives, it is found that it is now necessary to investigate the relationship between cash flow and construction sector performance.

2. Literature review

All components of the building project implementation process are influenced by cash flow. A lack of cash can result in project and business failure. Researchers have looked at cash flow in the context of project scheduling, delays, failure, and forecasting. Negative cash flow trends and patterns, on the other hand, have not been thoroughly investigated (Al-Joburi et al., 2012). Contractors that do not manage their cash flow effectively will not be able to compete in the construction market. According to studies and investigations, a shortage of cash is a major factor in construction project failure (Zayed & Liu, 2014). In construction management literature, cash flow is regarded in two ways. The first defines cash flow as the difference between the net receipt (cash in) and the net disbursement (cash out) of receipts and disbursements that occur within the same interest period (Liang et al., 2021). A positive cash flow, according to this school of thought, shows a net receipt in a certain period or year, whereas a negative cash flow suggests a net disbursement in the same period (Liang et al., 2021). In the construction industry, receipts (cash in) are mostly generated from monies received in the form of monthly payments, stage of work payments, the release of retention funds, and final account settlements. Disbursements (cash out) refer to the money spent on a contract to pay workers and subcontractors, purchase materials and blueprints, and so on (Liang et al., 2021). The

second definition of cash flow in construction management is the actual movement or transfer of money into or out of a corporation. Money going into a business is referred to as positive cash flow (+ve) and is credited as cash received by this school. Negative cash flow (-ve) refers to money that has been paid out and is debited to the firm. The net cash flow is the difference between positive and negative cash flows. The first definition of cash flow is utilised in this study because it is broadly recognised by most contractors, widely used in the construction industry, and supported by numerous recent studies (Purnusa & Bodea, 2016).

Also, due to the critical necessity of cash flow, researchers have developed numerous cash flow forecasting and prediction methodologies for both owners and contractors, as well as for both short and long-term building projects. Chen (2007) suggested simple technologies that will make cash flow forecasting easier. McInnis and Collins (2011) looked into the impact of cash flow forecasting on project accounting. The reviewed research emphasised the critical significance of cash flow forecasting in predicting financial shortages and avoiding or at least decreasing negative cash flow situations.

Purnus and Bodea (2015) presented a viable cash flow analysis model that may be used by construction businesses when making decisions on project portfolio structure. Their suggested model allows construction companies to anticipate not only when but also how much money should be borrowed or received from internal or external sources and when and how much money should be returned. Construction project management concerns the context and attributes of projects to ensure that events adhere to plans and standards. Nonetheless, performance dissatisfaction is a widespread issue in the construction industry. A typical project may face a number of challenges that impair its performance in areas such as poor productivity (Makulwasaatudom et al., 2003).

Performance measurement is the process of determining how successful organisations or individuals have been in reaching their set goals. It is a mechanism for identifying sources of unnecessary waste so that the company can focus its resources where they are most needed. It shows the current state of play and, more importantly, the further direction of developments. Also, measurement can promote steady progress toward specified targets while also identifying inadequacies or stagnation. Measurement of performance is important because it indicates the status and direction of a project (Egwunatum, 2017). Performance measurement's purpose is to offer quick and accurate feedback on operational efficiency and effectiveness, as well as to keep the focus on continual development (Bassioni, 2004). Accordingly, it is clear that cash flow variation and contractors' financial management have a great effect on project performance, as emphasised by AL-Nassafi (2022).

A cost estimate, often known as a budget plan, is an estimate of a building project's overall cost, which includes materials and labour expenses, among other things. Cost estimation and planning are crucial in project management. The cost estimate must be precise, clear, and full since it is used for feasibility studies, design possibilities, and selecting the optimal design for a project. A time schedule and S-curve may be constructed based on construction planning for a project to be completed within the stipulated time periods after carefully assessing construction expenses (Gurcanli et al., 2017).

Construction project budgeting serves three purposes: (1) evaluating if present assets or finances are sufficient to pay expected building costs, (2) controlling money flow during the construction process, and (3) planning for a competitive construction bidding or negotiating process. The owner's ideas and requirements are used to calculate a building budget, as well as what the contractor understands and agrees to; it is useful in ensuring that construction works are completed properly and that the contractor receives an acceptable profit (Sharifi & Baghepor, 2016).

By regulating the financial situation — positive or negative balance — the Project Cash Flow (PCF) offers a foundation for the contractor to make suitable decisions for project continuity and success. The cash-in comes from current assets (self-funding), loan funds, and down payments. Direct expenses, indirect expenditures, contractor profit, and informal costs are all included in the cash-out (Reyers et al., 2015).

The following six elements have an impact on the PCF: (1) down payments and progress billings for piece work contracts, (2) progress schedules, (3) material schedules, (4) equipment schedules, (5) labour schedules, and (6) subcontractor payment schedules (Djatmiko, 2017). Purnus and Bodea (2016) noted that complete and regulated planning for project cash flow management should be created to deal with increased financial risks, high capital expenditures, market competitiveness, and other competitive concerns that construction businesses face.

According to Sharifi and Baghepor (2016), the PCF conditions are the most significant component of a construction project; hence, the planning and estimating process must be precise, rapid, and successful in dealing with risk factors. Because PCF correctness is critical, a complete and detailed investigation must be performed.

Purnus and Bodea (2016) stated that the length or start and end dates of a project, as well as the DP (Documents against Payment) payment interval and progress billing, are all criteria to consider while monitoring and assessing the PCF. The S-curve is necessary to make PCF deployment and outcomes evaluation easier. According to Lu and Liu (2014), the techniques for successful construction projects are to avoid wasted time, assure quality to get recognition from the owner, resolve conflicts through negotiation, and accelerate progress toward fulfilling work objectives.

One of the most typical issues in the construction sector is project delays. Many researchers have tried to figure out what is causing project delays. According to Abdul-Rahman et al. (2009), there are four main causes of building delays, all of which are tied to money: late payments, inadequate management of cash flow, financial market instability, and limited financial resources are all factors to consider.

From a list of 28 key explanations, Sambasivan & Yau (2007) selected the ten most significant reasons for the delay. They also divided the six primary effects of delay into categories. Four of these underlying elements have been shown as the most significant contributors to construction delays: instability in the contractor's financial foundation, poor financial and commercial management by the client, and issues receiving inflation and loans from financiers.

The construction industry uses the Critical Path Method/Program Evaluation and Review Technique (CPM/PERT) to minimise the overall project length. According to Elazouni and Gab-Allah (2004), many heuristic, optimum, and suboptimal techniques for altering CPM/PERT have been devised, but none of them uses cash flow availability as a variable in balancing project expenditures. Traditional resource allocation approaches, they believe, cannot be utilised to substitute finance-based scheduling since available cash flow is treated as a finite resource. They provide finance-based scheduling for constructing CPM/PERT using integer programming, allowing projects to be funded within certain credit constraints.

Finance-based schedules were also created utilising genetic algorithms to optimise project profit by lowering finance and indirect expenses (Elazouni & Metwally, 2007). Elazouni (2009) used a heuristic technique to apply finance-based scheduling to diverse projects. The Strength Pareto Evolutionary Algorithm is added to the finance-based scheduling, which enhances it even more (Abido & Elazouni, 2010).

When dealing with restricted cash flow, resource-based scheduling should be addressed, according to Liu and Wang (2008). In conclusion, many scholars have looked at the scheduling issue, but there is still no consensus on the best method for most building projects.

Davis et al. (1989), Abdul-Rahman (1993, 1995), Low and Yeo (1998), Love and Li (2000a), and Barber et al. (2000), among others, have emphasised the need to measure quality costs to enhance the performance of construction organisations and lower project costs. Quality costs are the overall expenses incurred as a result of issues that arise before and after the delivery of a product or service (Love et al., 1999). Internal and external forces contribute to the costs of failure. Internal low-quality expenses, such as rework, material waste, and other unnecessary process losses, raise an organisation's cost of operations.

Quality now stands next to Price as a major factor of differentiation in contractor selection by the client, as well as determining the efficiency of processes that the contractor adopts for site operations. To be competitive and sustain good business prospects, construction companies need a more strategic orientation for the quality systems they deploy. The role of quality management for a construction company is not an isolated activity but intertwined with all the operational and managerial processes of the company. Quality in construction can be achieved only through the direct effort of all stakeholders of the project, which mainly depends on the availability of cash flow.

Human resources and construction operations have not placed enough emphasis on safety provision and practice. Over time, safety concerns have improved as the construction industry has demonstrated investment incentives and favourable consequences for customers and operators. In response to the rise of the construction sector, governments began to implement additional laws and norms for safety measures. Construction businesses began implementing safety action plans on their sites and projects as a result of the enforced laws (Ahmed & Kwan, 2000). Contractors are prepared to implement a qualified safety system for the work environ-

ment since it includes measures that boost their profit and competency by supporting an accident-free work environment. Clients and owners will also be motivated and happy to engage in the construction business since it complies with all environmental and safety laws. A successful qualified safety system for the work environment implementation will result in acceptable quality at a lower cost and more productivity (Koehn & Datta, 2003). Due to the lack of effective safety and building regulations, the construction industry in developed countries still performs poorly in terms of health and safety (Datta, 2000). Okoye (2014) stated that the building industry had made intensive steps to change its health and safety performance.

However, these initiatives have moved away from measuring safety efficiency and toward protective safety initiatives. In its efforts to address the transformative initiatives of several countries, the success of the industry's health and safety remains a glaring concern. Health and safety costs are widely regarded as required and beneficial business expenses (Okoye, 2014). Protection costs are paid to meet regulatory provisions for injury prevention, to enforce policies and avoid injuries during building projects, and to improve health and safety standards in all aspects of the work undertaken to ensure a stable work environment (Bima, 2015). Costs involved with proper safety criteria in developed nations can actually be unjustifiable, and creditors may be unable to pay the safety cost for economic stability if the actual cost of an accident is too low in the market (Smallwood, 2004).

Based on the above scenario, a clear gap is evident in studying the effect of cash flow variation on construction project performance. The importance of this study stemmed from the need to determine the causes and impacts of cash flow variation in Jordanian construction projects from the perspectives of contractors and their relationships with project performance. Examining this relationship may provide practitioners with the means to control cash flow variation and thus have a successful construction project. On the other hand, the current research bridges the gaps in the literature since little research have been found on the research subject in Jordan in the researchers' knowledge.

3. Research design and methodology

Quantitative research refers to the systematic search of social phenomena through statistical methods or mathematics. Quantitative research tries to create and use mathematical models, questions, and theories that are relevant to phenomena. Because it offers an effective link between empirical observation and mathematical articulation of quantitative relationships, the measuring process is the focus of quantitative research (Sekaran, 2010). Moore et al. (2006) argued that the questionnaire is a widely used data collection instrument due to its capability of gathering a large amount of information. This study adopted the descriptive analytical approach to collect data from the study sample, referring to theoretical literature related to the subject of the study and developing a questionnaire as the main tool to collect data from the study sample.

The research community means all the individuals of the phenomenon under consideration and includes the total set of individuals to which the researcher seeks to generalise the results related to the problem studied.

The respondents of the current study are project managers from contractor companies from all classes who operate within Jordan, approximately 340 construction companies in Jordan (Jordanian Construction Contractor Association, 2021). The reason for choosing these respondents is that they are the individuals most affected by this issue. In addition, the researcher considered the valuable data that could be gathered from this group.

According to Cavana et al. (2001), the required sample size for this study was approximately 173 individuals, as defined in the rules provided by Krejcie and Morgan (1970) for sample size decisions, as shown in Equation 1 below. According to Leveugle (2009), the Krejcie and Morgan equation provides a 95 % confidence level and +/-5 % margin of error; therefore, utilising this equation, the study sample consists of 191 individuals in case of the occurrence of unusable data.

$$n = \frac{x^2 * N * P(1-P)}{(ME^2 * (N-1) + (x^2 * P * (1-P))} \quad (1)$$

where:
n = sample size,
X^2 = Chi-square for the specified confidence level at 1 degree of freedom,
N = population size,
P = population proportion (.50 in this method),
ME = desired margin of error (expressed as a proportion).

A selective sample was adopted, which is a form of non-probability sampling. Researchers employ this

strategy in investigations where random chance sampling is impractical to draw due to time or expense constraints, according to Zikmund, Babin, Carr, and Griffin (2013). Furthermore, with the selective sampling method, researchers choose samples solely based on their own knowledge and reputation. In other words, researchers select only those individuals whom they believe are suitable for participation in the study and have the right information.

191 questionnaires were distributed to the respondents through Google Drive. The online method was used because of and in accordance with COVID-19 government-mandated restrictions. A total of 181 valid questionnaires were retrieved for statistical analysis, accounting for (94.76 %) of all disseminated questionnaires, which is an acceptable percentage for scientific research.

The questionnaire utilised in this study was based on the Likert scale, with five options ranging from (strongly agree) to (strongly disagree). Each option was given a relative weight of 5-1. The following are the three key sections of the questionnaire: the First Section, concerned with the personal data of the respondents and their companies; the Second Section, concerned with the independent variable (cash flow variation); literature was used to develop this instrument (Al-Joburi et al., 2012; Djatmiko, 2017; Liang et al., 2021); and the Third Section, concerned with the dependent variable (project performance) with all its dimensions (Project Final Duration, Quality, Safety, and Final Cost); literature was used to develop this instrument (Guracanli et al., 2017; Lu & Liu, 2014; Oke et al., 2016).

The current study followed certain phases to achieve its objectives, wherein the design method of this study was derived from the literature to determine the suitable approach and instrument for this type of study. This study employed a questionnaire for data collection because it is a valid instrument, according to Moore et al. (2006), who argued that the questionnaire is a widely used data collection instrument due to its capability to gather a large amount of information. The following procedures were followed: to determine the study problem, define the study terms, pick the relevant tools for the research, and evaluate the theoretical literature and existing research relating to the subject of the current study.

The study population comprised individuals who deal with the Jordanian Construction Contractor Association, 2021. From that population, a selective sample was chosen. To collect data from the study sample, a questionnaire was developed, and the questionnaire's validity and reliability were confirmed, after which the researcher distributed 191 questionnaires to the respondents. A total of 181 valid questionnaires were retrieved for statistical analysis, which represents 94.76 % of the total distributed questionnaires. Data was collected from the distributed questionnaire and then analysed using the Statistical Analysis of Social Sciences program (SPSS 25.0) to achieve the study results. The study results were discussed, clarified, and compared with the results of previous studies, and some recommendations were proposed.

4. Data analysis and results

This section summarised the findings of the data analysis that was carried out to answer the research questions and achieve the research objectives through hypothesis testing.

Content validation and internal construction validation were employed to confirm the study tools' validity:

The research instrument was presented to a panel of six experienced and specialised arbitrators drawn from Mutah University's department heads and faculty members. The arbitrators were requested to comment on the comprehensiveness of the paragraphs, their area relevance, the suitable language construction, and the clarity of the paragraphs and to add, delete, or alter anything they thought was necessary. The arbitrators recommended that no para-

Tab. 1. Correlation coefficients between the individual's score on the paragraph and the overall score on the instrument

Item No.	Correlation coefficient	Item No.	Correlation coefficient	Item No.	Correlation coefficient
1.	.476**	15.	.413*	29.	.399*
2.	.434*	16.	.449*	30.	.462*
3.	.542**	17.	.544**	31.	.348*
4.	.465*	18.	.602**	32.	.568**
5.	.604**	19.	.379*	33.	.593**
6.	.375*	20.	.443*	34.	.611**
7.	.456*	21.	.374*	35.	.436*
8.	.567**	22.	.432*	36.	.387*
9.	.423*	23.	.572**	37.	.349*
10.	.385*	24.	.365*	38.	.465*
11.	.376*	25.	.493*	39.	.579**
12.	.542**	26.	.449**	40.	.564**
13.	.501*	27.	.610**	41.	.456*
14.	.571**	28.	.434*	42.	.604**

* means significant at the level (α≤0.05)

** means significant at the level (α≤0.01)

graphs be deleted and that some paragraphs in the study tool be rewritten.

The validity of the study tool was confirmed using the validity of the internal construction, in which the tool was applied to a 40-person exploratory sample, randomly selected from both within the study community and outside the study sample, and the correlation coefficient calculated between the individual's degree on the paragraph and its overall score on the tool. Table 1 shows that suitable scale indicators have been achieved for the study instrument, as correlation coefficients ranged between .611- .348, all of which are statistically significant at the level $\alpha \leq 0.05$ (Sekaran, 2010).

5. Reliability of the study instrument

The internal consistency of the study instrument was determined using Cronbach's alpha equation and the coefficient of internal consistency. The study instrument's internal consistency coefficient was determined by distributing it to a group of 40 random respondents, as indicated earlier.

Table 2 indicated that the Cronbach's Alpha coefficients for the dimensions of the dependent variable (project performance) ranged between 0.80 – 0.82, while the Cronbach's Alpha coefficient for the independent variable is 0.80; these values are considered acceptable for the purposes of scientific research (Sekaran, 2010).

A descriptive analysis of the construct is addressed in the present study. The mean and standard deviation scores on the 42 items were obtained according to the study variables. After analysing the data to find the result that leads to reaching the first objective (investigate the causes of cash flow variation in Jordanian construction projects from the contractors' perspectives), the results of the descriptive analysis for the cash flow variation variable, the respondents indicate a high level of agreement for cash flow variation with a mean of 4.09 and a standard deviation of .581. The researcher attributes this result to the significance of cash flow for any project, as cash flow allows material procurement, salary payment, new project funding, and financing of other functions of the company's day-to-day operations. Our results have been supported by the finding of AL-Nassafi (2022).

In the construction supply chain, cash flow is also a concern, and it is a major cause of insolvency among contractors and subcontractors. This might be very critical for a project in terms of time and money. Even if a company is moderately successful, if positive cash flow is insufficient, a project may start to collapse owing to a lack of constant money throughout the project's life cycle.

This result may be attributed to the fact that the contractors are fully aware of the seriousness and importance of the issue of cash flow, so they calculate the cash flow accurately and in a scientific way that enables them to continue the project without any negative cash flow effects.

The current research result confirms the study by Djatmiko (2017), indicating that cash flow is related to all project elements and affects all of them. Also, this result agrees with studies by Purnusa and Bodea (2016) and Zayed and Liu (2014), which showed that cash flow could be affected by many factors, including bills of quantities, technical skills, and inadequate budget control, exactly as shown in this current study.

Table 3 shows the results of the descriptive analysis for the project performance variable; respondents indicate a high level of agreement for project performance with a mean of 4.01 and a standard deviation of .546, while at the level of dimensions, Quality came first with a mean 4.11 and at a high level, followed by Safety with a mean of 4.01 and at a high level, while Final Cost came third with a mean of 3.96 and at a high level, and, finally, Project Final Duration came fourth with a mean of 3.95 and at a high level.

This result may be explained by the fact that construction contractors pay great attention to the performance of the projects they undertake, especially with regard to their quality, as they must comply with all specifications accurately in addition to providing comprehensive knowledge about how to implement the quality system for project workers.

This result may also be attributed to the great attention given to the safety and security component in the performance of construction projects in Jordan, implementing procedures that consider the staff safety and security and providing mandatory individual health and safety training in the project, and the presence of a committee primarily responsible for public health and safety measures. This committee works within a set of laws and regulations related to health and safety in the workplace.

Before starting the regression analysis to test the study hypotheses, certain tests were performed to ensure that the data fit the assumptions of the regression analysis. It was confirmed that there was no high correlation between the independent variables (Mul-

ticollinearity) using the Variance Inflation Factor (VIF) test and the Tolerance test for each of the study variables, considering that the VIF did not exceed the value of 10 and the Tolerance value was greater than 0.05. Also, the researcher ensured that the data followed the normal distribution by calculating the Skewness coefficient, bearing in mind that the data follow a normal distribution if the Skewness coefficient is close to 0 (Awang, 2014). Table 4 shows the results of these tests.

The data in Table 4 indicated that the value of the VIF test for the independent variable was less than 10 and achieved 1.000 and that the value of the Tolerance test achieved 0.780, which is greater than 0.05; this is an indication that there is no high correlation between the independent variables (Multicollinearity). It was confirmed that the data followed a normal distribution by calculating the Skewness coefficient; the values were close to the value 0, which is less than 1, so it can be said that there is no real problem related to the normal distribution of the study data.

Table 5 shows that the value of the correlation coefficient for the independent variable (cash flow variation) and the dependent variable (project performance) together amounted to 0.805, and the value of the coefficient of determination (R2) was 0.648, meaning that the model explained 64.8 % of the total variance in project performance.

The researchers attribute this result to the circumstances that occurred due to cash flow problems. Construction companies may find it difficult to pay their bills and employees and order equipment, materials, and supplies for construction projects. Cash flow issues can also make it difficult for a corporation to form connections with general contractors and project owners. Construction companies cannot take

Tab. 2. Cronbach's alpha for the variables of the study instrument

Variable	Dimensions	Cronbach's alpha coefficient
Cash flow variation	Cash Flow Variation	0.80
Project performance	Project Final Duration	0.82
	Quality	0.81
	Safety	0.80
	Final Cost	0.82

Tab. 3. Descriptive Analysis for Project Performance

Rank	No.	Dimensions	Mean	SD	Level
4	1	Final Duration	3.95	.623	High
1	2	Quality	4.11	.682	High
2	3	Safety	4.01	.656	High
3	4	Final Cost	3.96	.632	High
		Average mean score of project performance	4.01	.546	High

Tab. 4. Test the VIF, tolerance, and skewness

Independent Variable	VIF	Tolerance	Skewness
Cash flow variation	1.000	.780	-.417

Tab. 5. Model summary of the impact of cash flow variation on project performance

Model	R	R^2	Adjusted R^2	Std. Error
1	.805	.648	.646	.32533

Tab. 6. Matrix of the Pearson correlation coefficient of the relationship between the cash flow variation and project performance with all its dimensions

Dependent variables	Independent variable	
	Cash flow variation	
	Pearson correlation	Sig
Project Final Duration	.742**	.000
Quality	.747**	.000
Safety	.665**	.000
Final Cost	.555**	.000
Project Performance	.805**	.000

** Statistically significant at the level (α≤0.01)

on new work or expand their business if they do not have the money to handle current tasks.

They also are not able to hire new employees or provide benefits or raises because the labour market is so tight. Cash flow affects all elements of construction projects, as it is responsible for determining the future obligations required by the project, determining the expected cost of the project, and anticipating the potential cost of the resources that will be required to complete all project work. This can have an important effect on the company's capacity to succeed. In fact, construction companies that have continuous cash flow issues are more likely to collapse. This result highlights the critical importance of the cash flow issue, which is one of the most significant practices in the management of construction projects, and the importance of calculating it accurately so that the owner and contractor can determine their financial needs and arrange them properly. Therefore, attention must be paid to the cash flow issue, and this is evident in how cash flow variation can impact project performance.

The above results agree with the findings of the studies by AL-Nassafi (2022) and Sharifi and Bagherpour (2016), which indicated the impact of cash flow variation on construction projects performance, and with the study by Al-Joburi et al. (2012), which mentioned that the quantity, time, and distribution of cash flow are all important elements in construction success, according to the report.

To investigate the relationship between project cash flow and individual measures of project performance, the researcher extracted the Pearson correlation coefficient between the cash flow variation and project performance; the results are shown in Table 6.

Table 6 indicates that all correlations are statistically significant and at positive levels between the independent variables represented by the cash flow variation and project performance as a dependent variable, whether at the overall level or at the one-dimensional level, and the total value of the correlation between the cash flow variation and project performance as a whole (0.805), which is a positive value that confirms the impact of the cash flow variation on project performance in Jordanian construction projects.

Also, the result showed that the strongest of these relationships was with the dimension Quality, with a correlation value of 0.747, while the weakest of these relationships was with the dimension Final Cost, with a correlation value of 0.555. This agrees with the results mentioned above in terms of importance, where Quality ranked first, followed by Safety, while Final Cost ranked third, and finally, Project Final Duration ranked fourth. Also, through the results shown, we found consistency, and the results didn't contradict the difference in the examination that was carried out. As stated earlier regarding the testing of the proposed hypothesis, they are examined as follows.

Conclusions

Based on the research results and discussion, the following conclusions can be presented:

- The state of a construction project's cash flow is a good predictor of its financial health, and cash flow issues are a common cause of the failure of construction projects.
- According to the study findings, construction projects are plagued by divergent cash flow with a mean of 4.09 and a standard deviation of .581, emphasising multiple reasons for differing cash flows in construction projects, including the lack of technical skills, different meanings of specifications, incomplete information at the tender stage, inadequate supplier management, and errors in project documents (Bills of Quanti
- Respondents indicated that the difference in cash flow affects all stages of construction projects, such as purchasing inventory and raw materials, and paying wages, causing delays in project completion time, lowering the profit margin, and increasing difficulties in obtaining financial aid.
- Respondents also indicated that they care greatly about the performance of construction projects, with a mean of 4.01 and a standard deviation of .546, as they focus on the success of these projects by adhering to the specified time to complete the project, maintaining the security and safety of all project workers, and implementing construction projects at a high level of quality.

The researchers recommended the necessary efforts to better understand the importance of cash flow by contractors to schedule project activities correctly and efficiently and the need to develop an accurate cash flow model with the aim of helping contractors and academics forecast cash flow before and during construction. In addition, more research is needed to examine the impact of cash flow on contractors, owners, and the industry as a whole, as well as factors that influence cash flow variation in construction projects in Jordan.

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Exploring the usability and user experience of social media apps through a text mining approach

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ABSTRACT
This study aims to evaluate the applicability of a text mining approach for extracting UUX-related issues from a dataset of user comments and not to evaluate the Instagram (IG) app. This study analyses textual data mined from reviews in English written by IG mobile application users. The article's authors used text mining (based on the LDA algorithm) to identify the main UUX-related topics. Next, they mapped the identified topics with known theoretical constructs to place them in their nomological network relevant to the usability (the 5Es framework by Quesenbery) and UX (the Honeycomb model by Morville). Finally, to expand the study with an emotional diagnosis, sentiment analysis was performed on two levels: (i) for each recognised topic, and (ii) for the full dataset to uncover general insights into users' emotions within all reviews. The case study of the IG app confirms the usefulness of user feedback data for software development and points out that the review data have the potential for the early detection of frustration and negative feelings introduced during the use of the application. Conducting conventional UUX evaluations with users is problematic since they are remotely located, and the user-generated content of a social app undergoes continuous and frequent changes. Thus, the consecutive stages of the proposed methodology, based on text mining algorithms, constitute a proposed framework for examining the user-perceived quality projection of applications from user feedback, and they are the main contribution of this article. The used approach can be valuable for helping developers, designers and researchers to reveal user problems and fulfil user satisfaction regarding UUX aspects for specific software features.

KEY WORDS
usability, user experience, 5Es model, honeycomb model, text mining, mobile apps

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Introduction

Social media, such as Instagram, Facebook, Twitter and many others, have become increasingly popular for communicating with other users and sharing user-generated content, mostly text, photos and videos. Social media users are exposed to targeted advertisements; thus, in fact, they are online customers who make choices driven by individually anticipated value.

For all software-based online services, usability and user experience (henceforth — UUX) have long been considered important factors that describe user-

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perceived quality, eventually determining the users' loyalty to a specific service. From the IT project management viewpoint, it was assumed that quality requirements should always be defined at the start of software product development (Berenbach et al., 2009). Furthermore, it was taken for granted that designers and developers have almost complete knowledge of the factors shaping software product quality. Most importantly for quality assurance, from the very early start of a project, frequent UUX evaluations are recommended, preferably with a sample of prospective users (Hartson & Pyla, 2012).

However, many online services (including social media) continuously evolve after deployment, while users and customers use them daily. To improve UUX and make a service or app more attractive, online service owners frequently add new functionalities, modify existing ones, and make various changes in data visualisations or other aspects of the user interface.

Contrary to classical software projects, users of online services are remotely located, and they are often eager to publish online their reactions to recently implemented changes. Users frequently post critical comments, especially if they find that specific modifications are too radical, make common tasks more complex, or just worsen their UX for any other reason.

As a result, in developing online services, despite conducting small-scale user-based pilot studies during design and development, it is never certain whether a specific community of users will widely accept specific user interface modifications.

There may also be many intangible factors that may attract or discourage users of a specific online service, such as the attractiveness of content published by other users, innovative functionalities to enhance social communication or service vendors' efforts to protect their users' privacy and security.

Gaining the trust of potential users of mobile applications is a continuous task that consists of many elements. These include, among others: attractive functionality and graphic design, the usability of the application, resilience to errors and the ability to produce instant value for the user, such as solving a specific problem. To achieve success, user comments should be constantly monitored, and the application should be adjusted to the users' expectations. A good application does not make users tired while using it or frustrated while browsing the functionalities of interest. It is this area, in a nutshell, UUX focuses on the basic principle of customer value orientation (Park et al., 2013; Adikari et al., 2011).

The validation of whether the application is useful and effective is carried out mainly through user-based research aimed at checking the level of user satisfaction. A group of representative users is usually employed as usability testers and interviewees. Obtaining this kind of information and analysing user behaviour are key elements for the entire UUX assurance process. This work aimed to propose a novel method of such an assessment based on the use of the text mining (TM) method.

Nakamura et al. (2022) revealed that so far, no method has been found yet specifically designed to analyse app store user reviews. Across their systematic literature review from 2012 to 2019, only five papers were found to apply a topic modelling method. However, a drawback of these studies is that the results of topic modelling are lists of terms which require a high cognitive load to interpret them. This study aims to fill this gap with a novel approach by introducing modifications, such as (i) labelling topics, (ii) mapping them to theoretical constructs from the field of UUX and (iii) including sentiment analysis to gain insight into the emotional dimensions of UUX. Therefore, focusing on filling this research gap, this paper aims to explore whether user opinions published online can be used:

- to disclose the main factors composing UUX for a pilot sample of Instagram users;
- as a projection of user-perceived quality, described especially as UUX;
- to reveal how users rate the IG mobile application and what emotions it evokes in them.

The classical text mining methods and algorithms were considered for this analysis. First, topic modelling based on Latent Dirichlet Allocation (LDA) was performed on user reviews to recognise the main topics in the dataset. Then, the identified topics were mapped with known theoretical constructs to place them in their nomological network and to identify factors composing usability and user experience. Finally, to reveal the emotional tone hidden in the reviews, a method of sentiment analysis was used.

The approach adopted of this study's authors is in line with the CRoss Industry Standard Process for Data Mining (CRISP-DM) framework, which comprises six phases: business understanding (consisting of research questions), data preparation and understanding, modelling, evaluation, and deployment (interpreted by the study authors). This framework is widely considered the most suitable and comprehen-

sive set of guiding rules for performing analytics projects (Abbasi et al., 2016).

The paper is organised as follows. A brief overview of UUX-related research is presented in Section 2. Section 3 is dedicated to the process of data collection and the methodology used in this study. In Section 4, the results are presented and discussed. Section 5 concludes the paper by presenting relevant limitations and the possibilities for further studies.

1. Related research

Usability and user experience constitute important quality attributes for software, websites and mobile applications. This section starts with a discussion on the concepts and components of usability, user experience and social user experience, respectively. Then, it discusses related studies concerning the application of the text mining approach for exploring UUX issues.

1.1. Usability

For software developers to facilitate the creation of high-quality software, the standard ISO/IEC 9241-11: 1998 specified usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Furthermore, the three principal usability components were defined (Bevan, 2008):

- effectiveness — the accuracy and completeness with which users achieve specified goals;
- efficiency — the resources expended to the accuracy and completeness with which users achieve goals;
- satisfaction — the comfort and acceptability of use, including "freedom from discomfort, and positive attitudes towards the use of the (specific) product, system, service or environment".

Soon after, the ISO/IEC 9126-1:2001 was published, specifying the following general quality characteristics for software products: functionality, reliability, efficiency, maintainability and usability. In this standard, usability was described by a different set of attributes, which causes some confusion, namely:

- learnability — the capability of the software product to enable the user to learn its application;
- understandability — the capability of the software product to enable the user to understand whether the software is suitable for a specific purpose and how it can be used for particular tasks and conditions of use;
- operability — the capability of the software product to enable the user to operate and control it;
- attractiveness — the capability of the software product to be attractive to the user;
- compliance — the capability of the software product to adhere to standards and conventions.

These attributes are surely significant for assuring high usability, but (except compliance) they are subject to individual susceptibility and far-from-objective assessment. For this reason, the terms specified in the earlier standard ISO/IEC 9241-11: 1998 were commonly operationalised for evaluation. Effectiveness was specified as user task completion rates and task completion times, respectively. Efficiency includes the relationship between an achieved task outcome and expended resources, such as time, mental effort and a number of steps or attempts to find support in the case of problems.

User satisfaction remains a purely subjective measure, so it is usually rated on a numerical scale, employing usability questionnaires or surveys. The identification of satisfaction components is usually performed using expert knowledge, user interviews or observations of the user activities in an actual context of use.

ISO-defined concepts of usability, unfortunately, require that the interpretation of usability components in each case (whether an office software, e-commerce website or social media mobile app) be made by choosing an adequate set of measurable characteristics suitable to a specific context of use, usage scenarios and user needs.

Deficiencies in ISO definitions for usability have been tackled by many researchers who attempted to adapt the understanding of usability to newly emerging systems and to rely mainly on the user's subjective assessment rather than on strict measurements.

For instance, Quesenbery (2004) proposed the "5Es" usability model, stating that a high-usability interactive product should be:

- effective — the software product helps to achieve the users' goals accurately;
- efficient — the software product provides the speed and accuracy with which tasks are successfully completed;
- engaging — the software product influences the emotions of the users, involving them in the pleasant, rewarding and interesting operation of a product;

- error-tolerant — the software product has the ability to help the user who commits errors or encounters other difficulties during product operation;
- easy-to-learn — the software product provides the user with both the initial orientation and, as the user's skill gradually advances, deeper understanding and guidance.

The 5Es usability model is more comprehensive than early ISO-based usability concepts, and it better highlights the need for the correct understanding of the local context of use by designers of a specific interactive product.

Furthermore, other researchers, such as Bevan (2008), Shneiderman and Plaisant (2016) or Sharp et al. (2023), among many others, have long promoted extending the notion of usability to encompass additional satisfaction factors typical for newly emerging systems (like games or online services), including flexibility, learnability, likability, pleasure, comfort and trust.

Subsequently, further revisions of ISO-based definitions of usability resulted in specifying a separate term, "quality in use" (ISO 925010:2011), which covers an expanded set of product quality aspects that are user-perceived during product operation.

Although the relevant ISO standards contain very detailed user interface guidelines and are an excellent source of reference, they are very time-consuming to employ in usability evaluations. Both expert-based and user-based evaluations have to be manually planned, performed and supervised by a researcher, which leaves room for subjectivity and unintended skipping of an important aspect shaping user satisfaction in a particular context (Hartson & Pyla, 2012).

This aspect proved especially important in usability evaluations of newly emerging systems, such as games, social media, websites, online services or mobile apps. In such systems, users are consumers and no longer system operators. Their satisfaction is shaped mostly by factors that are no longer task- or performance-related but largely emotional, like the pleasure of shopping in e-commerce, enjoyment and curiosity on social media, excitement and competition in games, or the convenience of instant booking in a mobile travel app.

Therefore, the term "user experience" was predominantly used. With its rapidly growing popularity, usability and all its task-related aspects were gradually absorbed into a novel notion of UX, discussed in the next section.

1.2. User experience

Building upon predetermined usability design goals, user experience (UX) has recently become the popular term covering additional quality criteria against which a digital product or service should be evaluated from the user's or consumer's viewpoint beyond task-focused usability.

Gradually, the term "user experience", initially introduced by Norman (1998), has emerged to cover the components of user interaction that go beyond conventional, task-related interpretations of satisfaction. Subsequently, the new ISO International Standard 9241-210 (2019) introduced the term meaning "a person's perceptions and responses that result from the use or anticipated use of a product, system or service". The users' perceptions and responses may include their emotions, beliefs, preferences, perceptions, comfort, behaviours and accomplishments, which occur in three phases: before, during and after using a specific digital product or service (Adikari et al., 2011).

In particular, with new technologies, such as the Web and mobile apps, users are not necessarily seeking to achieve a task but also to amuse and entertain themselves (Sánchez et al., 2012; Adikari et al., 2011; Blythe et al., 2003), for pleasure and hedonic qualities (Hassenzahl, 2004), which can also be considered a legitimate objective.

In and beyond the context of mobile apps, user experience is a consequence of the brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of a system, product or service (Park et al., 2013). It also results from a user's internal and physical state resulting from prior experiences, attitude, skills, abilities and personality relevant to a specific use context (Hassenzahl & Tractinsky, 2006).

Beyond ISO documents, different writers (Sutcliffe, 2009; McNamara & Kirakowski, 2006; McCarthy & Wright, 2004) have explored different aspects of and perspectives on the complexity of user experience in various contexts. Sadly, no common framework for measuring and assessing UX components has been established in IT-related development and research. Alternative models also leave a selection of meaningful UX components to a researcher's expertise and subjectivity.

Two of the most distinctive user experience concepts were proposed by Hassenzahl (2004) and Morville (2004). The hedonic/pragmatic model of user experience (Hassenzahl, 2004) assumes that people

perceive interactive products along two different dimensions. The pragmatic dimension refers to the product's perceived ability to support the achievement of specific objectives, like the outcome of a specific task (i.e., booking a hotel). On the contrary, the hedonic dimension refers to the product's perceived ability to perform a process in a smooth, confident and pleasant manner. For instance, it validates whether the process of hotel booking was visually attractive, transparent, and free from any frustrations, just reinforcing the user with positive emotions and memories.

According to Forlizzi and Battarbee (2004), user experience is always tied to actual use situations: to be valid, it cannot be separated from an actual experience of use during or after system operation by a specific user(s). Hassenzahl and Tractinsky (2006) strongly emphasised that user experience is always influenced by the user's internal state (predispositions, expectations, needs, motivation, mood etc.), the characteristics of the designed system (complexity, purpose, usability, functionality etc.) and the context (or environment) within which the interaction occurs (e.g., organisational/social setting, the meaningfulness of the activity, voluntariness of use, etc.). This view of user experience marks it as a definitely contextual construct, hard to formalise and unify; hence, it is rather more suitable for qualitative studies than for quantitative assessments.

Morville (2004) proposed the Honeycomb user experience model (Fig. 1), addressed mainly to the e-commerce domain, where the popularity of commercial websites and online services is very much shaped by the emotional load transferred by e-marketing tools and techniques. The Honeycomb model nowadays also applies to mobile apps, which are just another access channel for digital services, which used to be delivered primarily by websites when the model was created.

Fig. 1. Honeycomb user experience model

Source: Morville, 2004.

According to the Honeycomb model, an outstanding user experience is created by the consolidated outcome of the following interrelated components (Meuthia et al., 2021; Vivakaran & Neelamalar, 2015):

- useful — the app or service should deliver an outcome that is useful for the user;
- usable — ease of use is essential for usability (the accomplishment of the user's goal) but not sufficient to attract a user (consumer) for repetitive use;
- desirable — the combination of image, identity, brand and other elements of emotional design should make the service highly desirable for a specific segment of users;
- findable — the app or service (website) should be easy to navigate, and it should be easy to locate objects needed by users, i.e., by a local search engine or recommending tips;
- accessible — full access to the service functionality for impaired users is essential to avoid user frustration and disappointment beyond the legal requirements that are mandatory for public websites;
- credible — the app or service (website) should be trusted, instantly communicating credibility, competence and care, essential for hassle-free customer service;
- valuable — the app or service (website) must deliver value not only to project sponsors but primarily to users (customers), who would keep returning and remain loyal, ready to develop even stronger relationships in the future.

The Honeycomb model does not specify specific guidelines for delivering its user experience components, leaving particular means and solutions to be designed by qualified user experience designers and digital marketing specialists. Because user experience components in each case have to be individually identified, user experience evaluations must be based on extensive user research studies, interviews, surveys and user experience mapping workshops. The Honeycomb model addresses the product or service quality from the user's perspective, including primarily emotional responses and factors shaping further online customer behaviour.

Many studies from the e-commerce domain (Bilgihan, 2016; Eid, 2011; Chang & Chen, 2009; Chen et al., 2015) have shown that systematic, cumulative positive user experience episodes are essential for building online trust, customer loyalty and valuable relationships between online service providers

and specific segments of customers. Now, the popular concept of online Customer Relationship Management (e-CRM) is based on perfecting instances of user experience during single transactions and converting them into stimuli for strengthening customer relationships with a specific online service provider (Sikorski, 2008).

Attempts to discuss the complicated relationship between UX and the concepts of usability in the scientific literature were undertaken by Følstad and Rolfsen (2006) and Sauer et al. (2020). They conclude that usability is more objectively measurable than UX. According to Sauer et al. (2020), usability can be assessed by implementing more diverse methods, while there are fewer methods and instruments dedicated to UX.

To sum up, user experience appears as a complex concept which is difficult to measure objectively. Moreover, it extends the usability concept to the broad spectrum of users' perceptions during the usage of a product and/or service. Most importantly, the concept of user experience has taken the user's subjective emotional perspective, going far beyond the former perspective of task-related usability.

1.3. Social user experience

With the development of social media in the recent decade, the majority of e-commerce marketing communication with retail consumers was transferred to fan pages embedded in service providers' websites. As a result, the user experience of social media users nowadays is composed of "official" product-related content (if available) and user-generated content, like a relevant stream of photos, videos and texts, such as posts and comments.

With the further development of social media, the user experience concept needed to be extended to social user experience (social UX). Again, as in the case of "regular" user experience, no established, commonly accepted models could be used for social UX design and evaluation in social media or similar online services. Much of the relevant development work remains experimental (Saavedra et al., 2019), testing innovations by the trial-and-error scheme, or stuck in already accepted user interface design patterns, apparently reducing the risk of existing users rejecting novel solutions.

Väänänen-Vainio-Mattila et al. (2010) revealed that the main drivers of social UX include self-expression, reciprocity, learning and curiosity, whereas unsuitability of content and functionality, incompleteness of user networks and the lack of trust and privacy are often experienced as hindrances for social UX. Thus, the main guidelines for designing social UX are based on the general concept of sociability, interpreted as a feeling of togetherness and sheer pleasure in the company of others. As such, in other words, sociability exemplifies one's sociable conduct, not the personality characteristics of sociable conduct.

General guidelines for designing social UX were presented, for instance, by Pereira et al. (2010), who revisited the honeycomb pattern and defined key functional blocks recommended for a market-successful social software: presence, conversation, sharing, reputation, groups, relationships and identity. Building valuable social relationships by escalating user engagement can be pointed out as the culminating element, essential for retaining a loyal base of users/consumers.

Later, with further developments in social media and the growing anxieties of users as to possible abuses, their attitude changed to the increased role of perceived trust and the required activities of a service provider regarding adequate moderation of tone and emotions and user privacy protection and data security (Souza & Maciel, 2015).

Guidelines provided by the Norman Nielsen Group (2021) also provide an adequate set of tools for social networking and enable users to select specific types of communication or collaboration, depending on their needs.

The latter resembles the early concept of social UX, presented by Battarbee (2003), who proposed that the members of a specific community should themselves shape the scope and realisation of social UX. This means that a service provider should conduct systematic studies on how available communication tools are used, and look for improvements, also by watching what the competition is doing. Furthermore, while classical models viewed user experience as the subjective response in the individual's mind, its designers and developers had very limited opportunities to provide a satisfying user experience. By contrast, social UX in social media can be seen as an individual's reaction but also as something constructed in social interaction. Most importantly, Battarbee (2003) concluded that social UX is the experience that users themselves create together in social interaction. Subsequently, it is a service provider's responsibility to contribute to the design of positive social UX by creating a safe environment for users to engage in reinforcing activities and select

suitable personal communication artefacts, digital tools, environments and systems to facilitate this kind of use.

Contrary to software and websites, the formal evaluation of social UX, with the intention of making improvements, faces many problems. Social communication is an ongoing process, and any studies of this kind may resemble sampling water from a fast-flowing river. Furthermore, user experience workshops with social media users should be performed remotely, and even if skilfully moderated, they are unlikely to produce results directly applicable to user experience development teams.

The available research in the three areas presented above highlights important distinctions among the three concepts:

- usability — is task-related, relevant mostly to software products, and is assumed to be created/delivered by software product designers; usability can be evaluated partly by objective measurements and observations and supplemented by subjective user opinions;
- user experience — addresses emotional components, present mostly in e-commerce and other online services, where users are aware as consumers; relevant usability factors are incorporated into a specific UX, and they should be evaluated primarily by collecting and analysing subjective user opinions; positive UX is assumed to be largely created by UX designers during the design process;
- social UX — is co-created by users during social interactions; contrary to usability and UX, it cannot be created in advance in the design process by social media developers; they can only provide the appropriate tools and features for users to generate stunning user experiences, and evaluate user feedback from actual activities, posts and comments published online.

To conclude, as discussed in prior paragraphs of this section, existing UUX models have very limited applicability to social media. They are inconsistent, context-dependent, inadequate to user experience co-created by users on the go, and incapable of streamlining a typical, predefined user research process, as happens in UX design for most IT projects.

As social UX is co-created on the fly by a specific community of users, the following reflections come to mind:

- There is no "generic" social UX for social media; it is a local development limited to a specific community of users who collaborate for some time and tend to trust each other in online communication, sharing content and collaboratively co-creating a shared user experience, specific for this group of users.
- Social UX cannot be entirely designed in advance because its bricks are dynamically generated during social interactions taking place among members of a specific community.
- Because social UX is local, it is unlikely that an external researcher would be able to identify its components unless joining the group as a "mysterious member", which could clearly raise ethical concerns.
- Hence, why not let the users of a specific community reveal which factors are important for building a positive social UX in a specific online context? It could be done by encouraging them to use a dedicated forum to post opinions on problems experienced regarding UUX, or other complaints, but also by collecting UX-related innovative ideas or improvement suggestions (possibly rewarded within one of the gamification schemes).

In this study, resulting from the above literature review, the authors selected to use (i) the 5Es framework by Quesenbery (2004, 2014) to identify attributes related to usability and (ii) the Honeycomb model by Morville (2004, 2016) to identify the user experience dimensions. Both models have established precise definitions of the dimensions and clear demarcations of the differences between them.

The authors of this article decided to choose the 5Es framework because: (i) the model is simple, and its flexibility offers the opportunity to customise each app based on the needs of the users; (ii) its dimensions well encompass usability aspects; (iii) it is relatively rarely tested in scientific studies, and the authors aimed to bridge this gap; (iv) it balances function requirements with usability requirements; (v) its dimensions, taken together, are a tool to create a more precise description of both the goals for and engagement of users, and their experience of using applications. According to Quesenbery (2014), the usefulness of this framework "does not end with understanding users", but it suggests design approaches and may then be used to evaluate why an app's interface is failing or succeeding.

On the other hand, the choice of the Honeycomb model was motivated by: (i) its applicability and popularity in domains of e-commerce and other digital services; (ii) treating users as consumers who, aware of multiple options, choose the preferred ser-

vice provider; (iii) specifying complementary facets of UX, essential to convert user satisfaction into customer loyalty and valuable relationships online. Because social media apps are just interactive tools for building relationships based on users' emotions, the Honeycomb model was found suitable as a basis for user experience evaluation in a social media context, with opportunities for its prospective extensions.

1.4. Application of text mining methods for exploring UUX

The mining of user reviews has received enormous attention in recent years in many areas. Paradoxically, there are quite a few research studies focused on using TM methods for mining UUX issues/strengths based on textual data, mainly user reviews. Below, the discussion concerns those related to artefacts similar to the topic addressed in this article.

Bakiu and Guzman (2017) used a collocation algorithm to extract the features, lexical sentiment analysis to uncover user satisfaction with a particular feature, and machine learning to detect the specific UUX issues affecting the software application. Maalej and Pagano (2011) reported how user feedback could be considered in software development. In a subsequent paper, Pagano and Maalej (2013) analysed the text content and rating characteristics of user feedback from mobile application distribution platforms (i.e., app stores), which allow for the development of requirements from distributed users. Carreño and Winbladh (2013) processed user opinions to extract the main mentioned topics and some sentences representative of those topics. They revealed that this information could be useful for requirements engineers to look through the requirements for subsequent releases.

In turn, Jacob and Harrison (2013) considered mobile app reviews as a valuable source of ideas coming directly from app users. Thus, they analysed mobile app feature requests from online reviews. They designed the MARA system (Mobile App Review Analyzer), which is a prototype developed to mine for and retrieve feature requests from online reviews of mobile apps. The results of the evaluation were further analysed using Latent Dirichlet Allocation for identifying common topics across feature requests. Their study uncovered that most of the user requests refer to improved support for apps, more frequent updates, new levels for game apps, and more customisation options. In turn, Guzman et al. (2015) presented DIVERSE, a feature and sentiment-centric retrieval approach which automatically provides developers with a diverse sample of user reviews. They compared the reviews retrieved by DIVERSE with a feature-based retrieval approach and found that DIVERSE outperforms the baseline approach. Whereas Hedegaard and Simonsen (2013) examined the content of online reviews with the aim of discovering the distribution of information in reviews among different dimensions of UUX, and extracting associated keywords for each dimension using techniques from natural language processing and machine learning.

The scientific literature on the examined topic also provides works covering other systems and not related to mobile applications. For instance, Jiménes et al. (2018) reported on an approach based on text mining techniques to quickly identify usability and functionality drawbacks in a learning management system. By using these techniques, they identified more than ten usability issues and the need for seven new functionalities to be implemented in the system.

Another strand of research includes studies using sentiment analysis. Thus, Portugal and Leite (2018) studied the use of sentiment analysis to help find relationships among usability-related quality requirements in GitHub's projects. They aimed to find a list of sentiment expressions that would characterise significant relationships between usability and other qualities through text mining. Their approach yielded early positive signs.

On the other hand, Weichbroth and Baj-Rogowska (2018) used the sentiment analysis method intending to extract positive and negative keywords from user opinions of the WhatsApp mobile app. Finally, the reported problems were thematically mapped into seven attributes of usability and eight dimensions of user experience. Thus, the authors proved that online reviews reveal genuine usability and user experience issues.

This article's authors propose a different approach based on topic modelling, initially proposed by Debortoli et al. (2016) and expanded with a sentiment analysis to gain insight into the emotional dimensions of UUX.

The availability of user review datasets for mobile apps opens an opportunity to test whether text mining could help identify UUX-related factors (extracted as topics) that seem important to specific users. Thus, this paper aims to find answers to the following research questions (RQs) related to the dataset of reviews about the IG mobile application:

RQ1. What are the user-perceived components of UUX for the IG mobile app based on the selected models (presented in Section 3)? In other words, how do IG users — in the light of reviews — fit into the UUX components and what is the percentage share of each facet in the applied models?

RQ2. Are all components of both models covered/present in the textual dataset?

RQ3. What is the engagement of IG users in the topics discussed in various facets of UUX?

RQ4. Does the user review dataset have the potential for the early detection of frustration, negative feelings (e.g., brand image deterioration, weakening brand relationship), and changes (e.g., user interface, functionality, layout, etc.) introduced during the use of the application/service?

RQ5. How do users rate the IG mobile application (in the light of sentiment analysis), and what emotions does it evoke in them? Which topics trigger negative emotions?

2. Research Methodology

To answer all the RQs, this section presents the methodology applied in the study. The research methodology part is divided into two main sub-sections. Section 2.1 aims to briefly discuss data collection to create a textual dataset ready for further analysis. Then, Section 2.2 describes in detail the data analysis steps performed in the current study.

2.1. Data

The IG mobile app is available on the App Store and Google Play. This very popular app is used by its users to easily express themselves and connect with friends by (i) adding photos and videos to their Stories; (ii) messaging their friends, sharing and connecting over what is seen on their feed and Stories; (iii) creating and discovering short, entertaining videos on Instagram with Reels; (iv) posting photos and videos to the feed that one wants to show on a profile.

After downloading the app, users can write online reviews about their experience using it. Mobile app store reviews are not usually very long, and they are written and submitted from mobile devices, on which typing is not as easy as on a desktop (Fu et al., 2013).

However, such feedback constitutes an important source of information for the app developer (Instagram, Inc.) and allows developers to interact directly with potential consumers, which may help in the software development process (Cuadrado & Dueñas, 2012). Thus, data for this study cover Android and iOS mobile app reviews available respectively on Google Play and the App Store.

Since most websites do not offer APIs to access user reviews, text data were extracted from Internet sources via web crawling. In total, 567 reviews in English were downloaded, covering March 2020.

2.2. Data analysis

Fig. 2 presents the main steps of the research methodology adopted in this study. These issues are discussed in more detail later in this section. The R software was applied for the data analysis. According to Debortoli et al. (2016), there is no simple recipe for choosing the adequate combination of natural language preprocessing (NLP) steps, and a study's objective and its underlying dataset determine many of them. Due to this, after data collection, the corpus, representing a collection of text reviews about the IG app, was subjected to several preprocessing steps according to standard text mining procedures. First, punctuation marks (periods, commas, hyphens, etc.), numbers and white spaces were removed. Second, the characters in the entire corpus were converted to lowercase. Then, stopwords (extremely common words such as "and", "or", "not", "in", "is", etc.) were removed. Finally, to ensure the terms in the corpus were uniquely identified, Porter's stemming algorithm was used to perform stemming (Žižka et al., 2020).

This study focuses on discovering the hidden sub-themes in the corpus based on the Latent Dirichlet Allocation (LDA) modelling approach. The prepared dataset was first converted into a document-term matrix, which was then subjected to LDA using Gibbs sampling. The LDA algorithm calculates latent distributions of topics and words, given the observed occurrences of words in individual documents. The LDA algorithm was used because it gives better results in terms of generating semantically significant topics and assigning texts to identified topics (Omotosho, 2021). Moreover, LDA enables not only hidden topics to be identified but also the share of each topic in the corpus to be estimated.

First, preparation–modelling–evaluation cycles were performed to determine an appropriate number of topics to extract from the dataset. Five and ten topics were tested, but these less-grained topic models failed to suitably distinguish between topics.

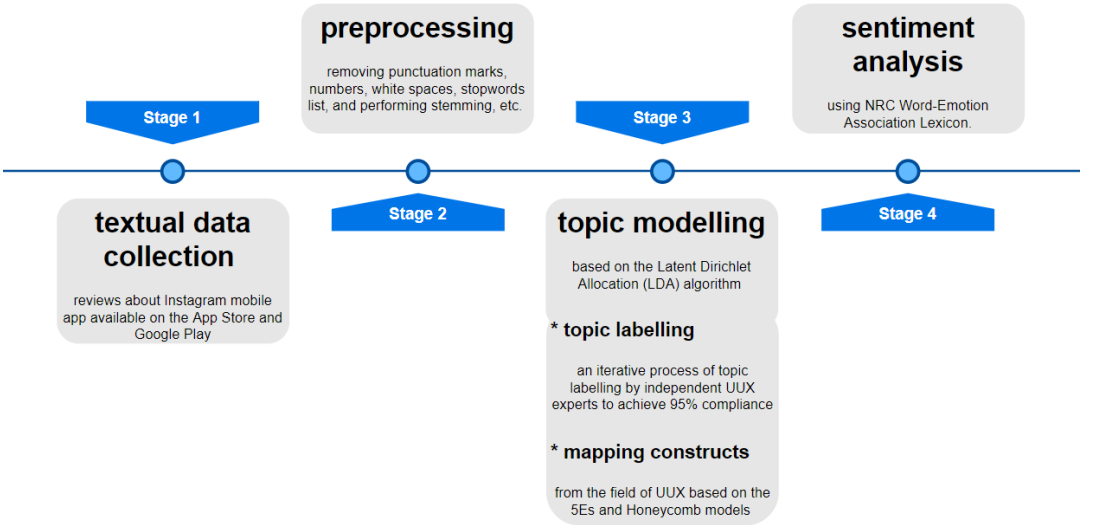

Fig. 2. Overview of the main steps of the approach

Finally, based on Rajkumar (2010) and Griffiths and Steyvers (2004), a 16-topic model was found to be optimal in terms of the average semantic coherence of the model. To validate topic models and evaluate their semantic qualities, the following questions were used following Boyd-Graber et al. (2014): (i) are individual topics meaningful, interpretable, coherent and useful?; (ii) are assignments of topics to documents meaningful, appropriate and useful?

Since each topic is actually a distribution over all words found in the corpus, topics described only by top-weighted keywords were obtained, and a labelling process was needed. According to Debortoli et al.

Tab. 1. Definitions of constructs related to the usability (the 5Es framework)

Construct	Definition	Source
Usability	"The capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions"	ISO/IEC 9126-1, 2001
	"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"	ISO9241-11, 1998
	"The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component"	IEEE Std.610.12-1990
Sub-construct: facets of the usability	Definition *(Users think that…)*	Identification questions *(Hints posted in user opinions: …)*
Effective	An effective product helps users achieve their goals (like completing a specific task or solving a specific problem) in a specific context	Were the user goals achieved as expected regarding completeness, accuracy and suitability to the specific context?
Efficient	An efficient product helps users achieve their goals with minimal use of resources (such as time, mental effort, manual operations, number of steps, etc.)	Were the user goals achieved with acceptable time and low mental and manual effort?
Engaging	An engaging product motivates users to further activities by presenting attractive visual cues, interesting information and stimulating guidance	Was using the product interesting, attractive and motivating for the users?
Error-tolerant	An error-tolerant product lets users continue their tasks by eliminating opportunities for errors and by providing easily reversible actions for errors that occurred	Was correcting user errors straightforward and effective?
Easy-to-learn	An easy-to-learn product supports users in initial orientation and deeper learning by reusing users' prior knowledge and skills	Was it easy to learn how to operate the product? Was the acquired skill easy to recover after a long break from using the product?

Tab. 2. Definitions of constructs related to user experience (the Honeycomb model)

Construct	Definition	Source
User experience	"Momentary, primarily evaluative feeling (...) while interacting with a product or service"	Hassenzahl, 2008
	"All aspects of the user experience when interacting with the product, service, environment or facility. (...) It includes all aspects of usability and desirability of a product, system or service from the user's perspective"	ISO 9241-210:2019
Sub-construct: facets of the UX	Definition *(Users think that...)*	Identification questions *(Hints posted in users' opinions: ...)*
Useful	A useful product satisfies user needs and enables producing an expected outcome (like accomplishing a task or solving a specific problem)	Does the product satisfy specific user needs and produce an expected outcome?
Usable	The expected outcome is accomplished at a reasonable expense of a user's resources (time, mental effort, manual operations, number of steps, amount of data input, etc.)	Is the outcome achieved in an easy and straightforward manner?
Desirable	The outcome of product operation is highly desirable, for instance, solving a problem, providing pleasure, convenience or a valuable relationship	Is the outcome desirable and motivating for repetitive use of the product?
Findable	Finding data and objects needed for accomplishing user goals is easy and straightforward	Are data and objects required to complete the task (data, buttons, menus, paths, search window, etc.) easy to find?
Accessible	A fully accessible product provides its complete functionality and contents for users with visual impairments and other disabilities	Are all functions and contents fully accessible for users with impairments or disabilities? Were any complaints collected regarding this issue?
Credible	A credible product (service) behaves in a predictable manner, exactly as expected by users. The same applies to its provider as to effective support in solving user problems	Is the product (service) trustworthy, supportive and protecting user privacy from harm and abuse?
Valuable	The product (service) is beneficial and attractive for users in building their positive attitudes and valuable relationships	Do users find the product (service, app) important, beneficial and valuable? Do they express positive emotions towards the service provider's brand? Would users recommend the IG app to friends and relatives?

(2016), at least two independent researchers should interpret and label the topics. Due to this, an iterative process of topic labelling was performed by two independent experts who deeply understand the UUX domain and its theoretical foundation. This stage was done in two iterations until consistent results were achieved.

To make sense of the recognised topics in relevance to existing theories, efforts were made to map the discovered topics to theoretical constructs of theories from the field of user experience and usability. First, constructs were mapped in relation to usability based on the 5Es framework by Quesenbery (2004; 2014). Then, Morville's (2004; 2016) user experience Honeycomb model was used to diagnose the UX value during mapping topics. Both models — 5Es and Honeycomb — provide a set of characteristics that can be used to organise and analyse information from IG users.

Both authors mapped topics with constructs independently based on a list of theoretical definitions and identification questions (Tables 1 and 2) to achieve at least 95 % compliance. Finally, all constructs from the two models were joined with the identified topics. The result of this stage is presented in Table A (available on the GitHub repository – https://github.com/Anna-TM-projects/-Exploring-Usability-and-User-Experience/blob/main/Appendix_Tab%20A.pdf).

While the facets of usability present its sub-constructs as the expected features of a product (software, app or website), the identification questions presented in Table 1 provide validation hints about whether a specific facet of usability was satisfied in the users' view. The information required for this validation can be sourced from the observations and measurements; however, as it was in this study, it was also collected from the text mining of user feedback published online.

The definition and identification questions of sub-constructs from both models were not derived solely from expert interpretations but arose from aggregated expertise from literature sources. Thus, 5Es were supported by Quesenbery (2001; 2003;

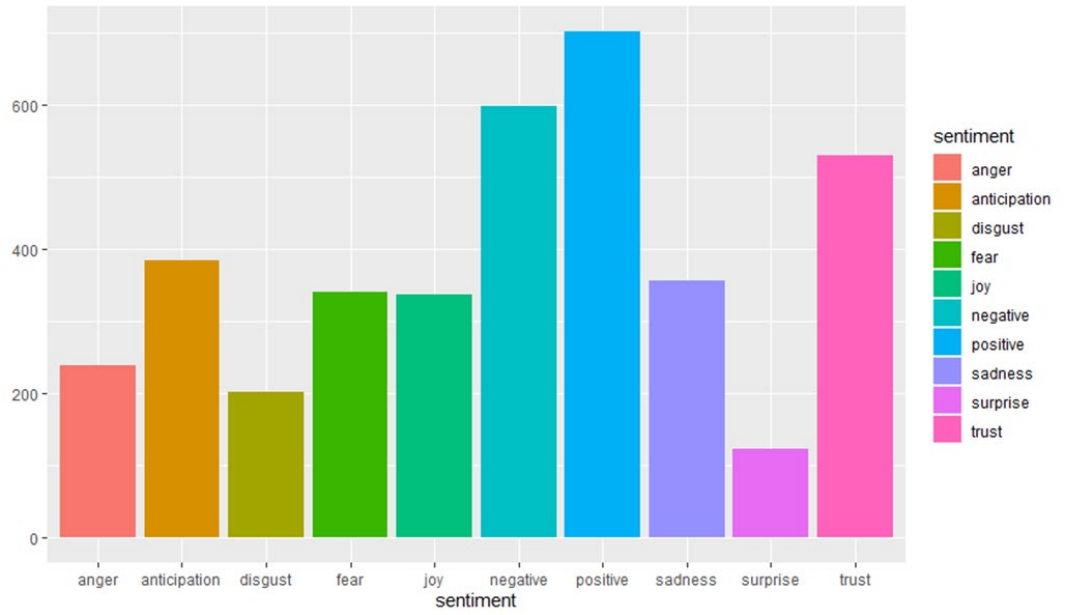

Fig. 3. Sentiment scores distribution in the IG dataset

Source: elaborated by the author in R software.

2004; 2014); Korhan and Ersoy (2016), Häkkilä et al. (2005), Kumar and Mohite (2018), Liu et al. (2018) and Wang and Brennan (2017). Whereas Table 2 presents the "user experience" definition for the Honeycomb model from two sources and its facets derived from aggregated expertise from literature sources (Morville, 2004; 2016; Hartson & Pyla, 2012; Meuthia et al., 2021; Vivakaran & Neelamalar, 2015).

The identification questions presented in Table 2 provide validation regarding whether a specific facet of user experience was satisfied in the users' opinion and relevant to a particular product or service (predominantly, a website or mobile app). The information required for this validation can be sourced from direct observations or emotional responses, but primarily, as it was in this study, for mobile apps, it should be collected directly from users and by the text mining of user feedback published online.

Each facet of the Honeycomb model can provide help as a singular-looking glass, enabling the exploration beyond the standard way. Similarly, insights from the 5Es model can be extracted in terms of the usability of the IG app. This way, each user need statement can be turned into UUX goals or requirements. Thus, calculations were made to find the share of topics (in per cents) included in the facets of each model. This way, information was obtained about how IG users with their reviews fit into the UUX components and what was the percentage share of each facet (Figs. A and B in the Appendix).

A sentiment analysis (SA) was performed to expand the context of this study with emotional information. First, SA was performed for the full dataset to detect general insights into user emotions within all reviews. NRC Word-Emotion Association Lexicon was used to perform this kind of SA. Due to this choice, it was possible to use pairs of opposite emotions from Plutchik's Wheel (Cardone et al., 2021) as a base, i.e., joy as the opposite of sadness, fear — anger, anticipation — surprise, disgust — trust. Plutchik's Model of Emotions (PME) organises feelings and makes sense of them logically, and for this reason, it is used very often. Fig. 3 visualises counts of emotions detected within the full set of IG reviews.

Subsequently, sentiment analysis was also performed for each of the 16 topics at a binary level (positive or negative sentiment). The results are shown in Fig. C in the Appendix.

The analysis of the sentiment for each topic was based on two categories of opinions: positive and negative. Then, the Net Sentiment Rate (NSR) was calculated, according to Baj-Rogowska (2020), by adding a standardised interpretation of the index result as well. The following algorithm was used for the computation of the Net Sentiment Rate:

$$NSR = \frac{(PO-NO)}{(PO+NO)} \quad (1)$$

where: PO — positive opinions, NO — negative opinions. NSR ∈ (-1; 1), where: -1 — opinions are totally

negative, 1 — opinions are totally positive.

Whereas to define the strength of the net sentiment, the following classification was applied (Baj-Rogowska, 2020):

- $0.0 < |\,NSR\,| \leq 0.1$ — weak positive/negative sentiment,
- $0.1 < |\,NSR\,| \leq 0.3$ — average positive/negative sentiment,
- $0.3 < |\,NSR\,| \leq 0.5$ — high positive/negative sentiment,
- $0.5 < |\,NSR\,| \leq 0.8$ — very high positive/negative sentiment,
- $0.8 < |\,NSR\,| < 1.0$ — almost complete positive/negative sentiment.

The outcomes provided by the algorithms provided information not only on the user perception of an examined issue in a binary way (negative or positive) but also provided insights into more sophisticated emotions, such as disgust or trust. This provided us with quite comprehensive insights into the issue regarding the content of Instagram reviews.

3. Results and Discussion

Many experiments were performed within the textual dataset analysis, providing the following results. First, the topic modelling study showed how, based on naturally occurring text data in the form of user reviews, it is possible to attain user experience and point out usability attributes (RQ1). The relationship between the topics and the recalled theories from Section 3 of this paper is presented in Table A (available on the GitHub repository – https://github.com/Anna-TM-projects/-Exploring-Usability-and-User-Experience/blob/main/Appendix_Tab%20A.pdf). Sixteen inductively identified topics were mapped to the existing theoretical constructs from the UUX area, thus forming a nomological network. The results showed that the aspects Usable (50 %) and Useful (31 %) had the strongest presence in the set of reviews.

According to the definitions (Tables 1 and 2) and based on SA, the IG app is useful or/and meaningful and does satisfy specific needs or solve specific user problems. Users perceived it as easy to-use and trouble-free, in general. According to Porat and Tractinsky (2012), more useful products evoke a higher level of pleasure, which may, in turn, generate the desire of users to repeat the experience and continue using the application (Cockburn et al., 2017).

On the other hand, user engagement in the topics attributed to the usability facets (the 5Es model) points out that Engaging and Effective were covered the most often in user feedback. Thus, based on the construct definitions (Table 1) and SA outcomes, it can be very generally maintained that users perceive the IG app as engaging, pleasant and satisfying to use. The app's functionalities are engaging and appropriate to the tasks, users and context, and the users appreciate using this app. In addition, during the use of the IG app, the user goals are met successfully, in general, although there have been negative experiences connected with the subjects presented in Table 3. According to Quesenbery (2004), the relationship between the 5Es facets recognised in the study can set the direction for the interface design and help determine the techniques for user research and usability evaluation during a project. This may suggest design approaches and recognise places where changes are necessary to meet user needs.

Furthermore, the analyses did not identify additional explanatory factors, which go beyond the existing UUX theories, and all facets from the two models were present in the textual dataset (RQ2).

To answer RQ3, the obtained results were visualised and presented in Figs. A and B, in the Appendix. They show that the highest user engagement of IG users in the topics discussed in the Honeycomb model concerns two facets, namely, Usable (50 %) and Useful (31 %). In the 5Es model, facets concerning usability are the highest in the area of Engaging (30 %) and Effective (23 %). In turn, the lowest includes the area Efficient (9 %). This confirms the earlier remark that the IG app, to a small extent, may cause some of the difficulties that its users are exposed to.

Jacob and Harrison (2013) claimed that mobile app reviews were valuable repositories of remarks and ideas coming directly from app users. According to Guzman et al. (2015), it is important to consider user feedback when creating and maintaining useful and usable software. Our study also provides evidence in this scope. In answer to RQ4, we can say that we gain knowledge about general problems reported by users by identifying topics with negative sentiment (Table 3), as well as discovering knowledge about positive user remarks from positive sentiment. This information might be helpful for the early detection of frustration and negative feelings, identifying missing features and changes in terms of, e.g., user interface, functionality, layout, etc., and could finally bring an improvement in software quality. This has also

Tab. 3. Topics with negative sentiment

Topic No	Topic Label	NSR value	The strength of the net sentiment
#1	The app's changes (unsuccessful/frustrating)	-0.1724	average negative sentiment
#2	Technical problems	-0.3005	high negative sentiment
#8	Quality issues	-0.0136	weak negative sentiment
#9	Functionalities to be brought back	-0.1000	weak negative sentiment
#10	Issues of hiding story/viewer highlights	-0.4545	high negative sentiment
#11	Posts publishing	-0.1200	average negative sentiment
#13	Adding some options to switch on and off	-0.7000	very high negative sentiment
#15	User suggestions on what to fix	-0.6667	very high negative sentiment

Tab. 4. Sample reviews on the hot topic "Viewer lists are not available after 24 hours"

Review No	Rate (1–5)	Sample Reviews (original spelling)
# 191	Rated 1 star out of 5	"wait, what? we can't watch the viewers on our own stories (the ones with more than 24 hours in archives)? this is bad. really very bad. what are you guys doing!! bring our privacy back! what was wrong earlier if we can see who viewed our own stories after 24 hours???!!!"
#304	Rated 4 stars out of 5	"I HATE this newest update for instastory: „Viewer lists arent available after 24 hours." ...it's INCONVENIENT and LESS USEFUL. I like to be able to see instastory-viewer-list whenever I want. I think it's way better if you change it back like it was before"
#330	Rated 1 star out of 5	"I want to see the viewers list after 24 hours. if people can check my highlights after 24 hours, then I should be able to see them. they go hand in hand! you shouldn't have tried to fix what isn't broken. #bringbacktheviewerslist"
#399	Rated 1 star out of 5	"Hate that we can no longer see who has viewed stories after 24 hours. Not everyone has the time to constantly check their viewers while their story is live. Also, what's the point of telling us how many viewers but not who? (Especially for close friends)"
#505	Rated 3 stars out of 5	"Please explain why you remove the feature who viewed my stories?!!! why only 24 hours?! ill rate back on 5 when that feature got back"
#555	Rated 2 stars out of 5	"*viewers list not available after 24hours* this new update, trust me is of no use. To be very honest it's horribleeee!? and this is needed to be changed :)"

been confirmed by Pagano and Bruegge (2013) and Pagano and Maalej (2013), who reported that users very often shared their needs, ideas and experiences in their reviews, thus users provide useful feedback to the application vendors and developers for improving software quality.

It is noteworthy that topics with negative sentiment are more related to features and functionality issues (e.g., "#9: Functionalities to be brought back", "#13: Adding some options to switch on and off" etc.), whereas positive topics are more connected to general perceptions and human aspects (e.g., "#14: Assessment of the Insta app", etc.). This is in line with Nakamura et al. (2022) and shows that unsatisfied users are willing to provide details about the functionalities and aspects that evoke frustration while giving positive reviews; they are prone to describing the overall qualities and aspects of the app.

In the full review collection, the hot topic (i.e., the largest number of reviews written) with high negative sentiment was "#10: Issues of hiding story/viewer highlights". Similar assessments were given to "#2: Technical problems". Examining the comments assigned to a given topic allows for obtaining more detailed information about the reported problems. Sample reviews about the reduction in viewing time

for Instagram Stories after the new update (#bringbacktheviewerslist) are given in Table 4. It clearly shows what users cannot accept and what they find very irritating. Meeting these expectations can prevent brand image deterioration and the weakening of the brand relationship.

In line with Pagano and Maalej (2013), it was also found that the spectrum of feedback quality was varied, from helpful opinions for other users and developers to useless noise to insults. Valuable and useful comments are present fairly often and include information about errors and app crashes, technical problems, feature requests etc. This helps developers uncover user needs and experiences to develop the application in line with crowdsourcing requirements.

The study results also showed that most user feedback emerged shortly after new releases (i.e., a new update), and its frequency relatively quickly fell over time. Thus, analysing the feedback over several releases would help detect problematic features or other connected issues early.

Finally, to answer RQ5, sentiment analysis was performed per whole dataset (Fig. 3) and per single topic (Fig. C in the Appendix), and the results of emotion detection were presented by the visualisations. For the full dataset, joy and sadness were the first pair of emotions for analysis. Both emotions are on a relatively similar level, which means a similar number of reviews are happy and sad in the dataset.

The next comparison between fear and its opposite — anger — points out that users are very eager to share their experiences to publish their annoyance on the Web. As we first expected, the analysis confirmed that the IG mobile app topic brought lots of anger, stress and frustration. Further analysis indicated the causes of these negative emotions. The very high negative sentiment was connected with the following topics:

- #13 Adding some options to switch on and off (-0.7000)
- #15 User suggestions on what to fix (-0.6667)
- #10 Issues of hiding story/viewer highlights (-0.4545)
- #2 Technical problems (-0.3005)

The next pair of opposite emotions is anticipation, which was quite high in the reviews, and surprise, which had a comparatively low value. Anticipation is linked with curiosity and exploration.

Users seem to be looking for help when searching for solutions to their problems and are prone to exchange their experiences. Surprise is associated with something shocking or unexpected. This may imply that users are not finding many special shocking experiences for them connected with the IG app.

The last comparison, between disgust and trust, reveals a value of two-and-a-half times higher for trust than disgust. Disgust has a negative meaning and links to rejection, distrust or being uninterested. Whereas the value of trust in the entire set of emotions is superior to others. Due to this, we can conclude that IG users are recognized as being trusting and welcoming of the IG app.

To sum up, the SA revealed that in the entire dataset (Fig. 3), the positive sentiment of the reviews exceeded the negative sentiment. Users were more eager to share more positives than negatives while presenting their experiences with the IG app.

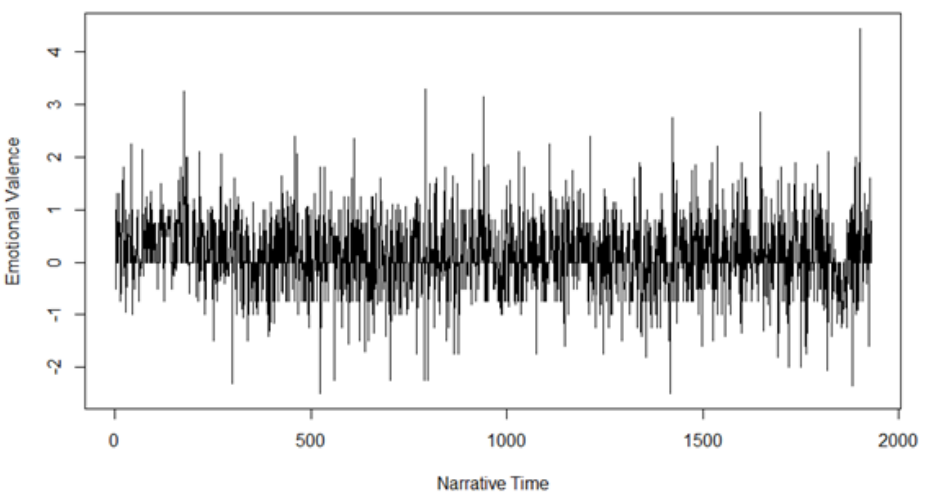

Fig. 4. Plot trajectory of emotional valence during a certain time in the full dataset
Source: elaborated by the author in R software.

Fig. 4 presents a moving average trend line for the full textual data to present how the sentiment of reviews developed over time. Data are presented in narrative time with the calculation of the mean sentiment valence for each time. This graph can be useful for getting a sense of the emotional trajectory of all reviews. From here, as well, it is clear that the distribution of positive and negative reviews is relatively even, and there are few outliers.

Because the main goal of this study was to evaluate the applicability of a text mining approach for extracting UUX-related issues from the dataset of user comments and opinions and not to evaluate the IG app, the most important conclusions and remarks are presented in the next section. This also includes potential novelties and contributions of this study to the science.

Conclusions

Starting from the IG example, this study aimed to perform a proof-of-concept of a novel approach, potentially opening new frontiers for UUX-focused exploration of available datasets of user comments and opinions regarding social media applications. The initial results seem promising, with some concluding remarks — achievements and limitations — presented below.

The present paper's contribution is fourfold. First, the study identifies, classifies and maps topics discussed in the user reviews into facets of two models from UUX. To the authors knowledge, this is the first such study in the literature. Second, the analyses pointed out that all facets of the two models were present in the user reviews dataset, which may confirm the usefulness of the methodology in software development and assessment. Third, a consolidated taxonomy chosen for this study was validated, and a clear definition of facets was created as well as identification questions for each of the two models to categorise the reviews. Fourth, the case study of the Instagram app confirmed the usefulness of user feedback data for software development and pointed out that the review data have the potential for the early detection of frustration, negative feelings (e.g., brand image deterioration, weakening brand relationship), and changes (e.g., user interface, functionality, layout, etc.) introduced during the use of the application.

Further validation of the approach should be conducted on all the proposed stages against a much larger text data set. Moreover, a good idea would be for future research to include a time perspective regarding each new app release, which could provide insights into UUX factors changing over time. In particular, modifications and changes that negatively — in the users' view — affect the functionality and user experience of mobile apps are frequently commented on online with obvious negative sentiment (Fashionunited, 2022; Digitalinformationworld, 2022). This provides an interesting opportunity for using text mining to analyse newly published user comments and to suggest responsive policies for service providers.

Definitely, the novel approach proposed in this paper requires more validation and further case studies, also aimed at reducing the limitations of this approach, briefly presented below.

First, in line with [Debortoli et al., 2016], we claim text mining methods such as topic modelling cannot replace human analysis, but should only accelerate and augment it. This is exactly the approach we recommend. However, a certain limitation of our approach is the time-consuming expert analyses.

Second, considering the assessments of experts (during labelling and mapping), the same results are not always obtained because the human factor is based on subjective feelings. To reduce the risk of researcher/expert bias, two researchers took part in the labelling and mapping processes, independently from each other, based on the prepared list of theoretical definitions and identification questions, achieving at least a 95 % compliance level.

Third, it is important to emphasise that the evaluation of UUX by analysing user feedback should not entirely replace the already existing methods but only complement them resolving limitations and provide quick, useful information for software development.

Finally, considering the findings of Hu et al. (2006) that reviews are mainly written by a group of very satisfied or very dissatisfied customers, no guarantees can be given that the set of reviews used for data processing was representative, i.e., whether it fully reflected the description of typical experiences in the user feedback base. In particular, despite the collected opinions being published only by IG mobile app users, no knowledge was available regarding the extent users' prior experiences (which surely existed in some cases) with the IG website could influence their opinions about the IG mobile app.

Hopefully, the approach can be useful for helping developers, designers and researchers to reveal user problems and helpful in fulfilling user satisfac-

tion regarding UUX aspects for specific software features. After further validation studies, this approach may prove useful for the early detection of UUX flaws for any online services which are already in use when their users are available only remotely and provided a dataset of their credible comments can be collected. If so, the text mining approach may open interesting opportunities for extracting information on UUX-related topics, such as sources of user discontent, frustration and annoyance. In the longer term, the input from text mining can be used in recovery procedures to identify problems, locate them in the system, prioritise and decide on further actions or mitigating policies. Last but not least, the text mining approach may offer an interesting advantage: additional possibilities for a focused view of user opinions by regions and languages according to users' locations, as far as possible, with a specific dataset.

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APPENDIX

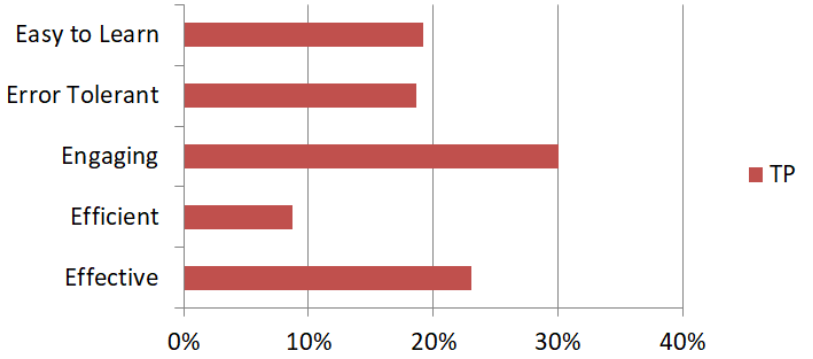

Fig. A. 5Es Model: user engagement in the discussed topics in the facets of Usability

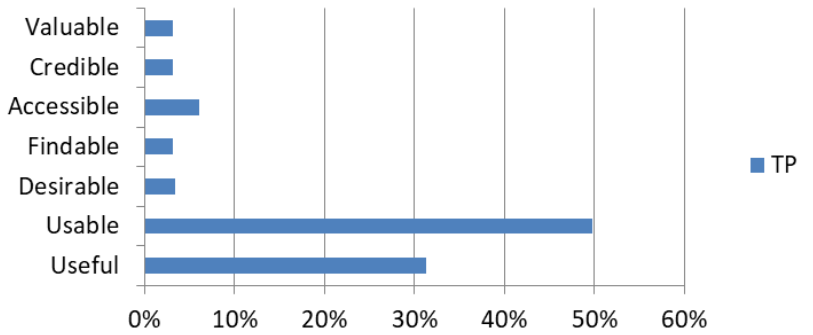

Fig. B. Honeycomb model: user engagement in the discussed topics in the facets of UX

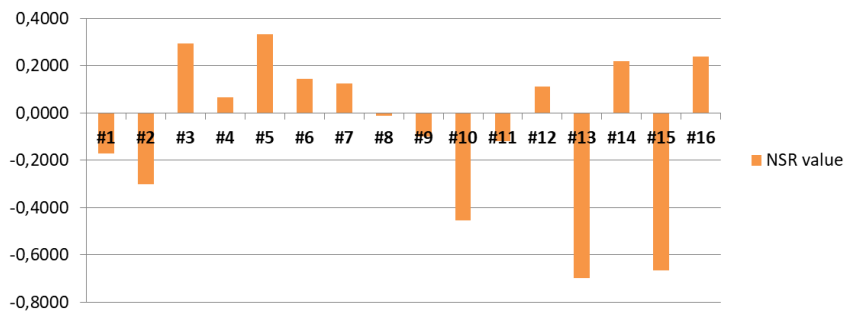

Fig. C. Sentiment distribution for each topic