

Schachtner, Christian; Jabłoński, Adam; Jabłoński, Marek

Article — Published Version

Determinants of Social Impact Through Safety Culture in Technical Organizations

Corporate Social Responsibility and Environmental Management

Provided in Cooperation with:

John Wiley & Sons

Suggested Citation: Schachtner, Christian; Jabłoński, Adam; Jabłoński, Marek (2025) : Determinants of Social Impact Through Safety Culture in Technical Organizations, Corporate Social Responsibility and Environmental Management, ISSN 1535-3966, John Wiley & Sons, Inc., Chichester, UK, Vol. 32, Iss. 6, pp. 8598-8624,
<https://doi.org/10.1002/csr.70151>

This Version is available at:

<https://hdl.handle.net/10419/335637>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

RESEARCH ARTICLE OPEN ACCESS

Determinants of Social Impact Through Safety Culture in Technical Organizations

Christian Schachtner¹  | Adam Jabłoński²  | Marek Jabłoński² ¹RheinMain University of Applied Sciences, Wiesbaden, Germany | ²WSB Merito University, Poznań, Poland**Correspondence:** Christian Schachtner (christian.schachtner@hs-rm.de)**Received:** 8 July 2025 | **Revised:** 13 August 2025 | **Accepted:** 23 August 2025**Funding:** The authors received no specific funding for this work.**Keywords:** safety culture | social impact | technical organization

ABSTRACT

The aim of the article is to show the results of research on whether safety culture is the social impact of technical organizations. It is important to fix determinants of social impact through safety culture in technical organizations. Positive safety culture is the result of consistent management actions aimed at both the inner workings of the company and its external environment. A safety culture should ensure that the risks associated with operational processes are mitigated in the context of adverse events such as disasters, accidents, incidents, law infringements, and so forth. Safety is a social good, which is the foundation and priority of people's quality of life. Meeting the safety needs of society is the task of responsible managers of technical organizations. The proposed analytical and research model has been used to analyze the factors shaping a safety culture in the context of their importance in the implementation of social impacts. The Vester and AHP methods were used to assess the impact of defined individual factors of shaping a safety culture and to determine the ranking of factors with the highest weights. The article is a step towards defining the processes of shaping a safety culture of technical organizations in the context of their social impact.

1 | Introduction

Safety management mechanisms in the modern world are a key attribute of well-managed enterprises. The complex ecosystem in which organizations conduct their business processes is often complicated, and due to its complexity, it can generate numerous uncontrolled events that threaten not only the organization itself but also the various groups of actors gathered around it. In this sense, the ecosystem imposes specific requirements on the businesses within that they must fulfill. This particularly applies to technical organizations that operate in dangerous, complicated, and uncertain conditions. Then their action must be based on a high level of reliability, as even one single accident can have far-reaching social, economic, environmental, and social consequences. High reliability can be achieved

by shaping an appropriate safety culture that builds the proper safety climate to ensure the safe conduct of all processes in the organization. A positive safety culture is the result of consistent management actions aimed at the inside of the company and its external environment.

1.1 | Background

The background for the research and considerations is the fact that companies currently operate in a multi-crisis environment, impacting them directly and indirectly, both internally and externally. They must not only navigate these crises but, above all, maintain their ability to survive and generate growth and development at all costs.

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *Corporate Social Responsibility and Environmental Management* published by ERP Environment and John Wiley & Sons Ltd.

1.2 | The Research Problem

The research problem and its significant cognitive gap concern answering the research question: What are the key determinants of social impact created by the implementation and development of a safety culture in technical organizations?

A positive organizational climate can be a suitable and very powerful platform for fostering positive management intentions among all participants in a given enterprise, which translates into the foundation for shaping a safety culture within the organization. This positive orientation strongly influences the scope, nature, and appropriate conditions and functions of employees' work. In other words, an appropriate climate creates the foundation for a strong and positive safety culture. Safety climate then serves as a dedicated measure and a way to perceive and interpret how specific safety is considered and constructed by employees at every level and function of the organization in their daily work. Examining and verifying the safety climate in a given enterprise is a proven tool that allows for the development of the desired image and form of a specific safety culture prevailing and defining safety principles within a given organization.

In contemporary times, the susceptibility of IT system environments to security threats is evident not solely within extensive industrial domains but also within the realms of small and medium-sized enterprises (SMEs), experiencing recurring cycles of vulnerability. The prevalent deficiencies in the information technology infrastructure, notably highlighted as due to successful hacking incidents and subsequent system failures, underscore the critical nature of the situation. As per a survey conducted by BITKOM, the repercussions of these incidents translated into a cumulative economic and public sector loss of 202.7 billion euros in Germany, as an example, during the year 2022 (BITKOM Research 2022).

A safety culture should ensure that the risks associated with operational processes are mitigated in the context of adverse events such as disasters, accidents, incidents, law infringements, and so forth. According to the authors, a positive safety culture is a key social impact as far as technical reliability organizations are concerned. For many organizations, reliability and its assurance are a priority in decision-making processes, both at the strategic level and within the processes and projects operating in various types of organizations. This also applies to manufactured products and services provided.

Their specific activity should be monitored through the prism of social impact. In this perspective, social impact is and can be understood from both positive and negative perspectives. In the positive perspective, it is related to the broadly understood trust that users of technical systems have in their safety criteria. It is assumed that safe technical systems prevent a number of accidents and disasters during their use and operation, which did not occur because the reliability mechanisms built into them prevented them. In the negative perspective, social impact refers to the consequences of adverse events, which can result in loss of life and health of people (employees operating a given technical system or bystanders). In this sense, any interference with human life or health inherently generates social impact. To achieve an appropriate and acceptable state in this area, comprehensive implementation of public safety

principles, development of trust management systems for various stakeholder groups, and ensuring continuous compliance with current legal requirements are necessary. Safety is a social good, which is the foundation and priority of people's quality of life. The scientific justification for this approach and interpretation is that it applies to every aspect of human life. Every person operates within a series of interwoven socio-technical systems, generating both positive values and benefits, as well as threats. A proper understanding of the interdependencies occurring at the interface between social and technical systems opens the way and space for informed decision-making by managers to generate platforms for ensuring the safe use of this technical, social, and organizational-managerial potential. Furthermore, such an interpretation generates new directions for scientific research to observe the complexity of systems in terms of safety. Meeting the security needs of society is the task of responsible managers of technical organizations. They must be aware of the impact of management decisions on ensuring the expected level of process safety. Providing a common, coherent basis for understanding and measuring social impacts in organizations, projects, and programs of technical organizations is a contemporary management challenge. This pro-social orientation covers, in particular, safety issues, which are operationalized through the development of a positive security culture. A symbiosis of technical and social processes should be maintained in the context of the organization's impact on the level of safety of stakeholders. From this perspective, safety can be interpreted as a state in which all threats are under control. This applies to an organization's processes, projects, and infrastructure.

1.3 | Objective and Scope

The aim of the article is to present the results of scientific research into safety culture as the social impact of a technical organization. The scope of this article encompasses technical organizations as creators of a specific organizational culture based on safety criteria. The subject of the research and discussion in this article refers to safety culture as a concept that is part of the assumptions of social impact.

1.4 | Methods

The adopted research methods apply the Vester and AHP methods to the processes of examining the determinants of social impact through safety culture in technical organizations. The choice of these methods is not accidental but deliberate. In the processes of examining social impact through safety culture in technical organizations, it seems fully justified, especially with regard to the analytical capabilities and synthesizing possible conclusions resulting from the application of these methods. These methods help identify and/or rank a set of factors determining safety culture in technical organizations in accordance with the adopted ranking principles.

1.5 | Key Findings, Implications

The article also presents key findings and implications arising from the conducted research, its conclusions, and final recommendations.

2 | Technical Organizations as the Creators of a Specific Organizational Culture

Organizations including technical enterprises are those whose main activity is based on technology or technical knowledge. These factors primarily determine their functioning, including their capabilities and technical and organizational limitations. This is especially true now, when the ongoing transformation resulting from the multidimensional and synergistic application of automation, robotics, technical diagnostics, IT, cybernetics, and broadly defined digitization is completely changing the logic of modern enterprise management principles. The purpose of this chapter is to demonstrate how technical organizations positively cultivate and develop a unique safety culture. The technology organization environment (TOE) is important here. It is a theoretical framework developed by Tornatzky and Fleischer in 1990, which identifies the characteristics of the technology, in particular the company's organizational readiness and environmental conditions as key factors for the adoption of a particular technology. The TOE framework assumes three basic contexts: technological, organizational, and environmental (Tornatzky and Fleischer 1990). The technological context takes into account available technologies relevant to the company, both internally and externally, which can be useful in improving the productivity of the organization. The organizational context is oriented towards defined resources supporting the acceptance of innovation. The environmental context represents the environment in which the company operates and is influenced by industry rules, its competitors, the company's ability to access resources, including those supplied by others, and interactions with the government (Lippert and Govindarajulu 2006). Another important concept in terms of identifying the characteristics of technological organizations is Roger's diffusion of innovation (DOI) theory. The DOI theory explains how specific attributes (factors) of innovation enable it to be adopted. It defines five key areas, namely relative advantage, compatibility, complexity, observability, and trialability. Relative advantage refers to the degree to which the person introducing the innovation perceives that innovation provides features or benefits that replace the existing system. Compatibility refers to the extent to which innovation fits into existing values, past practices, and the current needs of the innovation adopter. Complexity refers to the level of understanding of the complexity of innovation. The logic of this concept is strongly linked to the human factor, which leads directly to cause-and-effect relationships with social influence, which strongly influences an organization's safety culture. Innovations are created by people, and their initial implementation in technical and social systems can always generate potential threats. These threats can be mitigated through implemented mechanisms that shape safety culture. Observability refers to the extent to which innovation is visible to others. Trialability refers to the extent to which innovation can be experimented to a limited basic extent (Rogers 2010). Managerial behavior that prevails in such organizations is oriented towards the improvement of technical culture, which is shaped by behavior focused on professionalism in action, thinking, and understanding of technical systems and recognition of their leading role in human life. The technical organization sets its main objective of action on the basis of reasonable technical improvement in all

possible aspects of its activities. It understands the humanistic approach where a person must function in technical systems, entering into interfaces with different objects and technical systems. In this way, a specific understanding of the environment in which the technical organization operates is shaped. The technical approach is based on dividing the business ecosystem into parts—that is, those that can be separated from a larger whole, at the same time being inherent parts of the system. After separation, the process of improvement of each part of the technical system follows. This approach stems from the theory of building an interactive technical system, considered as a set of strongly interconnected components in a system-subsystem-component-element configuration. This creates an appropriate architecture for a technical system with a component structure. The interconnections within this system define the security criteria for the entire technical system and its individual components. This way of improving the world is based on technical thinking and management. The technical culture is then based on a similar understanding of the phenomena taking place where every element of the technical and organizational landscape should be improved by proposing increasingly better solutions. Technical organizations are strongly linked to science in this respect. Science stimulates the ability of these organizations to produce new products and services (Chanaron and Jolly 1999). Technical reasoning then forms the basis for analyzing and synthesizing solutions related to both the technique and the organization of work, and in particular the methods of organization management. The relationship between technical objects and the behavior of people towards them is an element that requires attention. The human–technical object interface in terms of modern conditions for creating innovative technical solutions is a key aspect of understanding social phenomena. Technologies force human interaction with technical creations. They need to shape people's behavior towards the complexity of social systems based on the intensity of technical solutions. The organizational culture requires a better understanding, given the increasing intensity of technical solutions in the business space. Organizational culture is a fundamental platform for shaping various types of organizational and individual behaviors that determine the achievement of specific strategic, tactical, and operational goals of the organization.

In this interpretation, the concept of social influence through the development and development of a safety culture within technical organizations takes on particular significance. Most threats affecting people occur at the interface of various interconnected systems. A technical organization operates within two systems: in the social system, where employees implement processes supported by technical solutions, and in the technical system, where machines and devices determine the feasibility of given products and services. The greatest risk is generated at the interface between the social and technical systems. This safety culture provides a platform for creating an acceptable level of safety within these systems and at their interface.

The susceptibility observed in the digital realm is ostensibly a consequence of a confluence of factors including inadequate financial resources for technological updates, deficiencies in IT strategy, and a deficiency in expertise. Safeguarding information

constitutes a strategic imperative at the highest echelons of management. Significantly, fostering a security- and risk-centric organizational culture, heightening awareness within specialized departments, formulating measurable criteria within a security strategy, and perpetually instigating a paradigm shift in employees' mentality, casting them as architects of their operational domains who act cognizant of continual cyber threats, hold paramount importance. In organizational contexts, scant attention is devoted to the formulation of sophisticated frameworks for procedural data protection in accordance with ISO 27xxx, let alone the implementation of a technically oriented Information Security Management System (ISMS), despite the existence of legal obligations and an increasing awareness of the imperative nature thereof (BSI 2023).

The focus should not only be on human relationships, but on relationships between people in a technical system. Today's level of application of technology is increasing and forces organizations to pay attention to shaping organizational culture in the context of the impact of technical solutions on people's behavior towards them and towards themselves. The organizational culture of technical enterprises should therefore be considered differently than in common practice.

A pre-existing procedural model tailored for SMEs is already in place, known as CISIS12. This acronym stands for "Compliance and Information Security in Twelve Steps." CISIS12 (Critical Information Security Implementation Steps 12) is a 12-step methodology for implementing an ISMS, developed primarily for SMEs. This methodology originated in Germany and is widely used among organizations seeking a practical, easier version of ISO 27001. An ISMS is a formalized ISMS, described in, among others, the ISO/IEC 27001 standard. It is not a step-by-step method, but a framework within which the organization itself defines processes, policies, and procedures. CISIS12 can be considered a path to an ISMS—especially for SMEs that are not immediately ready for the full ISO 27001 standard. If a company implements CISIS12, many ISMS elements will already be in place (policies, procedures, risk registers). Transitioning from CISIS12 to full ISO 27001 certification primarily requires supplementing the formal requirements of the standard. Evolving over a decade, CISIS12 has emerged as an ISMS, a culmination of insights gleaned from extensive surveys conducted among SMEs and authorities. These surveys, initiated by the IT Security and Safety Cluster, have significantly informed the development of CISIS12. The framework is strategically crafted to deploy information security processes both horizontally and vertically within a structured security model, emphasizing Risk Management (refer to IT Security Cluster e.V. 2023). There exists a notable disparity in administrative managers fulfilling their roles effectively within the realm of information security. This discrepancy can be attributed to various factors, such as technical intricacies or a lack of procedural oversight, resulting in inadequate resource allocation to the security domain.

By their very nature, technical enterprises create a specific type of organizational culture in which technology-related concepts play a key role, namely reliability, safety, and efficiency. Technical system operators, developers, designers, and managers monitor these parameters as they determine the key performance of these technical products and their functionality. The

organizational culture intersects with the technical culture, which is a sub-system of organizational culture—it is an inherent part thereof. The concurrent implementation of the objectives of organizational culture and technical culture determines the classification of enterprises as technical, where, as previously indicated, technology and technical knowledge determine the direction of their actions and development. In this way, a new interpretation of this type of organization emerges in the space of technical enterprises. The organizational culture in this sense should be standardized through the use of appropriate procedures and instructions consisting of a specific system of corporate management focused on specific objectives, mainly strategic and operational within the framework of the relationship between the strategy of operation and the business model adopted by a particular technical enterprise. It is the company's management system that operationalizes the assumptions for the implementation of operational tasks supporting the strategy that supports the technical trend. The business model, in turn, is based on attributes that are a coherent configuration resulting from access to and knowledge of technology, technical knowledge, and dynamics of reading market changes within the needs of improving the processes of value delivery to customers, often supported by technical solutions, which results from the assumptions of the functioning of such companies. A high-reliability organization is one of the technical organizations described above, where technological aspects, unambiguous professional and technical knowledge are the predominant attributes of defining such organizations. Their specificity includes the need to shape and improve a positive safety culture, the pursuit of a high level of reliability of operation, and the expected level of efficiency of operational processes.

3 | A High Reliability Organization as a Technical Organization Which Is Responsible for Shaping Safety Culture

3.1 | Definition and Characteristics of HRO

High reliability organizations (HROs) are a specific type of enterprise, especially in the context of the ecosystem in which they operate.

This specific ecosystem determines safety management mechanisms. In such a space based on the fulfillment of high safety and reliability criteria, key processes of this type of enterprise are conducted. The high reliability paradigm explains basic models for achieving reliable performance. The high reliability paradigm explains basic models for achieving reliable performance and examines HRO attributes and organizing processes that contribute to reliable performance in dynamic contexts (Sutcliffe 2011). There is a class of organization that can do catastrophic harm to themselves and the wider public. Within this larger set of potentially harmful organizations, there is a subset which have operated extraordinarily reliably over long periods of time. Operational reliability rivals short-term efficiency as major goals in these organizations. An extraordinary amount of attention is paid to operational reliability, both because of the inherent dangers of the situation and because outcome reliability is impossible to realize without operational reliability. Hence, we call these organizations "high reliability" organizations (Roberts 1989). HROs are organizations

with processes that have extremely low failure rates, because the costs of failures are extremely high (Hales and Chakravorty 2016). HROs have distinctive attributes and operate almost flawlessly in dangerous, complex and uncertain environments (Roberts 1990). HROs constantly search for errors, which indicate that they can lead to major failures and believe that, if they are identified and the response to these warnings is appropriate, such disasters may be prevented (Hopkins 2007). HROs refer to those organizations that usually operate in hazardous environments where the consequences of a process failure are extremely high (Baker et al. 2006). HROs are not immune to adverse events, but have learned to transform these occasional failures into increased system resilience (Reason 2000). An HRO is any organization that poses a certain risk to the population but maintains a failure-free action because failure is not an option (Bourrier 2011). They have the capacity to manage working conditions continuously and effectively (Busby and Iszatt-White 2014). HROs are organizations that operate potentially hazardous technical systems under very demanding conditions while maintaining a level of performance and safety far beyond expectations (Casler 2014), as well as being organizations that have not only avoided failure due to the happiness or whims of probability, but have successfully managed to control and reduce the risk of technical operations whose internal threats make them susceptible to catastrophic failures (Cox et al. 2006). HROs are also dangerous systems that provide “almost failure-free performance” (Hopkins 2007). HROs are organizations that show a strong sense of mission and operational objectives, emphasizing not only the objectives of ensuring ready production and service capacity, but also equal commitment to the reliability of operations and the readiness to invest in technology that ensures reliability, processes and human resources (La Porte 1996). They are organizations that are able to maintain excellent safety records for a long time, despite operating in a risky and dangerous environment (Lekka and Sugden 2011). HROs are organizations such as air carriers, nuclear power plants or volunteer fire brigades, which operate extremely reliably in a very precarious and dangerous environment (Mitropoulos and Cupido 2009), engaging in cognitive processes and activities aimed at actively avoiding seemingly unavoidable organizational and error-containing problems (Olde Scholtenhuis and Dorée 2014). HROs represent a group of organizations that are likely to operate with almost unblemished accident records, even though they operate in dangerous and complex environments in the course of their normal work (Pillay 2014). HROs have an organizational commitment to safety, with numerous system controls, checks and balances, and strong organizational learning cultures (Samuels 2010). HROs claim to be special organizations which consistently demonstrate safe performance in operating environments, which at the same time have high technical complexity, high consistency and high pace (Saunders 2015). HROs are organizations operating in an inexorable social and political environment, in an environment rich in the potential for error, in which the scale of the consequences excludes learning through experiments and where complex management processes of complex technology are used to avoid accidents in the face of changing sources of susceptibility (Weick et al. 2008). HROs are organizations capable of dealing with complex and dangerous activities at an acceptable level of efficiency with suitable human, technology and process management (Youngberg 2004). Below in Table 1 is a structured list of key definitions of HROs.

The content of these definitions clearly indicates the characteristics of a HRO in both technical and social terms.

3.2 | The Role of Mindfulness and Organizational Learning in the Context of HRO Development

Mindfulness plays a particular role in the HRO (Weick and Sutcliffe 2001). High reliability organizing is an important approach to crisis prevention and mitigation (Grabowski and Roberts 2019). The increasing havoc wrecked by catastrophic incidents on organizations worldwide, as well as the increasingly devastating effects of these incidents, have necessitated the development of a framework to improve the reliability of organizations. Despite operating in tightly coupled and complex technologies, HROs continue to operate mindfully with minimal incidents (Emele Agwu et al. 2019). HROs have gained strength and legitimacy from (1) studying ethnographically, with an organizational angle, high risk systems, (2) debating the principles of producing organizational reliability in the face of high complexity, and (3) integrating some of these principles into a generic model of “collective mindfulness,” with both practical and theoretical implications (Le Coze 2019a). In this sense, HROs can serve as a model for another type of organization in the context of the safety culture which they shape. This is particularly important in relation to the social impact determined by safety culture being built.

3.3 | Practical Applications of HRO for SMEs

In Germany, the standardization processes for SMEs are informed by the theoretical framework of awareness methods embedded within management approaches to learning concepts related to security infrastructure measures. A crucial distinction within the theoretical foundation involves two levels. Firstly, the content-oriented conveyance of the cybersecurity system, exemplified by the CISIS12 information security system tailored to simplify complexities for SMEs and municipalities. This model encompasses 12 steps, each comprising diverse building blocks. The emergence of “Compliance and related processes” as an essential new element signifies a strategic vision and guideline for understanding the significance of this topic. This includes structural specifications with technical standards, a catalog of measures, or an audit scheme aligning with criteria for excellence in security. References to relevant standards and catalogues, particularly those from ISO/IEC 27001, are integral. Additionally, integration possibilities for industry-specific standards and catalogues, such as TISAX and B3S-KRITIS, are considered. Supplementary documents, including a manual and training concept, along with software featuring project management, GDPR module, and document control, enhance the comprehensive approach. On the organizational, model, or software development side within the realm of IT security, methodical conceptual combination in the teaching of competencies is paramount. Adhering to the Action Design Research (ADR) approach outlined by Sein (2011), the process involves an analysis phase of real requirements, followed by a design phase aligned with successful implementation. Distinct phases within this model include:

TABLE 1 | List of key definitions of HROs.

L.P.	Definition of HROs
1.	HRO attributes and organizing processes that contribute to reliable performance in dynamic contexts (Sutcliffe 2011).
2.	There is a class of organization that can do catastrophic harm to themselves and the wider public. Within this larger set of potentially harmful organizations, there is a subset which have operated extraordinarily reliably over long periods of time. Operational reliability rivals short-term efficiency as major goals in these organizations. An extraordinary amount of attention is paid to operational reliability, both because of the inherent dangers of the situation and because outcome reliability is impossible to realize without operational reliability. Hence, we call these organizations “high reliability” organizations (Roberts 1989)
3.	High reliability organizations (HROs) are organizations with processes that have extremely low failure rates, because the costs of failures are extremely high (Hales and Chakravorty 2016).
4.	High reliability organizations (HROs) have distinctive attributes and operate almost flawlessly in dangerous, complex and uncertain environments (Roberts 1990).
5.	HROs constantly search for errors which indicate that they can lead to major failures and believe that, if they are identified and the response to these warnings is appropriate, such disasters may be prevented (Hopkins 2007).
6.	High reliability organizations (HROs) refer to those organizations that usually operate in hazardous environments where the consequences of a process failure are extremely high (Baker et al. 2006).
7.	High reliability organizations are not immune to adverse events, but have learned to transform these occasional failures into increased system resilience (Reason 2000). An HRO is any organization that poses a certain risk to the population but maintains a failure-free action because failure is not an option (Bourrier 2011).
8.	They have the capacity to manage working conditions continuously and effectively (Busby and Iszatt-White 2014).
9.	HROs are organizations that operate potentially hazardous technical systems under very demanding conditions while maintaining a level of performance and safety far beyond expectations (Casler 2014).
10.	Organizations that have not only avoided failure due to the happiness or whims of probability, but have successfully managed to control and reduce the risk of technical operations whose internal threats make them susceptible to catastrophic failures (Cox et al. 2006).
11.	HROs are also dangerous systems that provide “almost failure-free performance” (Hopkins 2007).
12.	HROs are organizations that show a strong sense of mission and operational objectives, emphasizing not only the objectives of ensuring ready production and service capacity, but also equal commitment to the reliability of operations and the readiness to invest in technology that ensures reliability, processes and human resources (La Porte 1996).
13.	They are organizations that are able to maintain excellent safety records for a long time, despite operating in a risky and dangerous environment (Lekka and Sugden 2011).
14.	HROs are organizations such as air carriers, nuclear power plants or volunteer fire brigades, which operate extremely reliably in a very precarious and dangerous environment (Mitropoulos and Cupido 2009).
15.	Engaging in cognitive processes and activities aimed at actively avoiding seemingly unavoidable organizational and error-containing problems (Olde Scholtenhuis and Dorée 2014).
16.	HROs represent a group of organizations that are likely to operate with almost unblemished accident records, even though they operate in dangerous and complex environments in the course of their normal work (Pillay 2014).
17.	HROs have an organizational commitment to safety, with numerous system controls, checks and balances, and strong organizational learning cultures (Samuels 2010).
18.	HROs claim to be special organizations which consistently demonstrate safe performance in operating environments, which at the same time have high technical complexity, high consistency and high pace (Saunders 2015).
19.	HROs are organizations operating in an inexorable social and political environment, in an environment rich in the potential for error, in which the scale of the consequences excludes learning through experiments and where complex management processes of complex technology are used to avoid accidents in the face of changing sources of susceptibility (Weick et al. 2008).
20.	HROs are organizations capable of dealing with complex and dangerous activities at an acceptable level of efficiency with suitable human, technology and process management (Youngberg 2004).

Source: Own study.

1. Problem analysis: Exploratory interest focuses on narrowing down the causes of problems through methodical questioning, employing game-based learning methods.
2. Design: Game-based learning and a modular haptic process support system are designed in correspondence with the CISIS12 system, encompassing “Building Information Security,” “Compliance Processes and Applications,” and “Risk Management,” alongside preparatory governance for decision-makers.
3. Evaluation and further development: Practical determination of the acceptance of game-based learning methods for the target group of business/authority management, coupled with necessary adjustments to differentiate between various process elements. Long-term workshops with operational staff are conducted to evaluate implementation details, leading to the development or adaptation of manageable and user-friendly forms of visualization.

4 | Safety Culture as a Concept That Is Part of the Assumptions of Social Impact

Safety culture is an important subculture of the organizational culture of a highly technical organization. It has a positive impact on the safety climate of companies performing safety-critical tasks. In this area, a crucial question can be asked about how the concept of safety culture fits into the assumptions of a social impact on a broad range of recipients of value proposition generated by such companies. In order to answer this question, the literature on safety culture needs to be reviewed in terms of its place and role in creating the social dimension. Safety culture is now an important and pervasive notion which has been used over the years to frame the problem of safety from an organizational perspective in different high-risk systems (e.g., nuclear, rail, oil, and gas) (Le Coze 2019b). It is generally considered that safety culture has a largely implicit, tacit core, common values, beliefs, basic assumptions, and so forth, and manifests itself in artifacts such as formal and informal outfits, buildings, rituals, and behaviors and verbal expressions such as statements and explanations (Guldenmund 2010). The concept of safety culture was widely developed by Nick Pidgeon, who believes that safety culture determines human mediation in the occurrence of accidents and disasters resulting from the coincidence of many different causes. Accidents are usually preceded by the non-concurrent occurrence of errors in risk assessment and technology selection, operational errors, faulty technical operations, various kinds of mistakes, or failure to comply with safety regulations, which individually do not usually lead to unwanted dangerous events. Only the accumulation thereof increases the likelihood of the simultaneous occurrence of events constituting a prerequisite for disaster (Pidgeon 1991). Safety culture is part of an organizational culture, which is believed to have an impact on members' attitudes and behavior in relation to the organization's ongoing health and safety activities (Cooper 2000). Safety culture is the entirety of material and non-material elements of man's well-established work, used to cultivate, recover (when lost) and raise the level of safety of certain entities. It can be considered in an individual dimension—a mental-spiritual, social, and physical (material) dimension (Piwowski 2015).

The elements shaping safety culture can be understood and considered as an aggregated set of attributes constituting it, with an appropriate configuration. This configuration of these elements should be consistent with each other. This allows for organizational synergy at the level of processes and projects implemented by the technical organization, with a safety criterion. The set of these elements may differ from organization to organization, but some elements within this set may be mandatory. They can then serve as the framework for a technical safety culture structure dedicated to the organization. Safety culture is created on an ongoing basis by interactions between entities in the context of an organization, which must adapt to its environment and ensure the integration of all its members (European Union Agency For Railways 2018). Safety culture is closely linked to the safety climate, which is related to the way employees perceive different safety-related issues in their company (Zohar 1980). Consequently, determining the factors affecting the formation of a safety culture is crucial to understanding the overall safety culture system and promoting proactive changes in the safety culture of an enterprise or organization (Wang and Liu 2012). The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventative measures (Health and Safety Executive 1999). There is a close relationship between the maturity of the organization and its safety culture (Filho and Waterson 2018). It also exists to strengthen the message and the seriousness of Total Safety Culture (Geller 1994). The human factor is of particular importance in shaping safety culture (Reason 1990). Even though the technology, infrastructure, and socio-cultural contexts differ, companies in different transport domains face similar organizational challenges related to: (i) the human factors influencing operators' strengths and weaknesses; (ii) the organizational management systems developed to contain and reduce the effects of the operators' weaknesses and fully utilize their strengths; and (iii) safety culture (Nævestad et al. 2018).

Firms have used different approaches to determining the social impacts of their actions. However, identifying and quantifying firms' social impact remain a challenge (Tello 2020). Social impacts may have diverse dimensions: they can be positive and negative, short-term or long-term, large-scale or small-scale, real or perceived (Vanclay et al. 2015). Social impact research develops requirements for a deeper understanding of the social processes in place. In line with the idea of sociological imagination, the social impact researcher should be capable of acting between individual, societal, and cultural understandings and drawing links between these three dimensions (Sairinen et al. 2021). Social impact includes not only short-term but also long-term societal effects (Maas and Liket 2011). Impact refers to an activity's consequences for the wider community (Bagnoli and Megali 2011). Social impact should be differentiated from social change processes (e.g., demographic, economic, and geographic processes), which cause social impacts. A social change process is “a discrete, observable and describable process which changes the characteristics

of (parts of) a society, taking place regardless of the societal context” (Slootweg et al. 2001). Social impact should be scaled. Scaling social impact is an ongoing process of increasing the magnitude of both quantitative and qualitative positive changes in society by addressing pressing social problems at individual and/or systemic levels through one or more scaling paths (Islam 2020). The conceptualization of social accounting has symbolic power (Killian and O’Regan 2016). Figure 1 describes the relationship between the features of a technical organization and the factors of safety culture in the context of social impact.

Social impact consists of actions aimed at internal and external aspects related to the functioning of technical organizations. The features of this type of organization are largely based on ensuring the low incidence of errors while being aware of the extremely negative impact of accidents. A safety culture helps a technical organization maintain a high and expected level of safety of operational and work processes. The features of technical organizations should, through a positive safety culture, ensure the social impact expected by stakeholders (Figure 1).

In the context of formulating an internal strategy for the implementation of the change process within an ISMS ecosystem, activities can be systematically categorized across three key dimensions.

Firstly, the Assessment of the Current State of Information Security Compliance Understanding involves a comprehensive definition of “compliance,” encompassing several critical aspects. These include introducing a procedural view towards compliance fulfillment, implementing a level-based ranking that considers both internal and external specifications, assigning responsibility at the managerial level, establishing compliance as the basis for decision-making in relevant processes, setting an implementation standard for applications, IT infrastructure, and buildings, and outlining the requirement for overarching PDCA cycles (Plan-Do-Check-Act). This category provides insights into the current landscape within the German public administration. Diverse perspectives and experiences

among experts portray a nuanced picture of how the German administration addresses changes in central systems, ranging from intentional ignorance to selective handling within a confined circle.

Secondly, the Exploration of Opportunities for Systemic Risk Management in Cybersecurity involves understanding the target group’s perspective on risk management. This entails the introduction of a systematic management approach, structured implementation of ISMS processes in risk assessment and evaluation, identification of core processes for recognizing “critical applications,” and the development and implementation of a charter with comprehensible decision-making criteria. Interviews reveal goals of approximation and attitude within the target group, marked by the use of adjectives such as “better” or “higher.” Despite the still vague solution orientation for systemic approaches, differentiating areas emerge, emphasizing a positive connotation within the target group.

Thirdly, the Development of a Systematic Transformation Model to Enhance ISMS Implementation aims to establish an innovative culture with operational realization of defined goals and long-term desired changes. This is achieved through the exemplary representation of dependency relationships during the practical steps for establishing an organization-wide system for risk impact assessment. This involves implementing a triangular ratio of elements, including Awareness/Sensitivity, Intention to act/behavior, and Ability to act (resources/structure and governance). Successful change and transformation require effective communication of opportunities, expectations, barriers, and potential assessments. Open and transparent handling of risks for all involved parties becomes a pivotal lever for measuring cultural aspects of leadership within the context of organizational transformation.

These categories, derived from in-depth workshops, provide crucial information for designing learning settings for decision-makers. Facilitating organizations in taking tangible steps for ISMS introduction following ISO standards of the 27xxx series necessitates a reduction in documentation obligations and abstraction levels. While the certification of internal personnel as implementing experts is important, it alone does not address the challenge of nationwide penetration. Top management’s comprehension of the link between IT security and other compliance requirements is crucial to determine appropriate resources and priorities. This is particularly evident in discussions about module 2: “Raising awareness among employees,” where a series of training courses for experts is planned as a fixed step. However, empirical results indicate that these measures often fall short of inducing actual behavioral changes in compliance without visible signs of leadership involvement (e.g., Weber and Schütz 2018).

From this perspective, the development of safety culture creates the conditions for creating the social impact of technical organizations. Safety is a social good, which is the expectation of modern civilization. In this case, building a configuration of safety culture components such that this impact is very strong is crucial. This should be expressed primarily by ensuring a high level of safety, that is, the absence of dangerous events in relation to human life and health.



FIGURE 1 | The relationship between the features of a technical organization and the factors of a safety culture in the context of social impact (own study).

5 | Safety Culture Components as a Source of the Social Impact of a Technical Organization

Safety culture must be built and developed wisely. In order to achieve this in a systemic way, it is necessary to determine the rules for its operationalization. The operationalization of safety culture is no easy task. This is mainly conditioned by skillfully reaching with its key assumptions every member of a given organization, who will not only follow said assumptions, but above all will be an active creator and supporter of its implementation. Shaping safety culture is a complex process. It requires its developers to use sophisticated solutions and tools to build a safety climate that stimulates the management of safety knowledge. At the same time, it is essential to ensure optimal working conditions by defining the principles of safety culture, including ensuring a certain level of safety, that is, the right working conditions and atmosphere, which is also manifested by the personal safety culture of each employee.

In this comprehensive analysis, several critical areas of focus and pertinent questions come to the forefront. Firstly, a meticulous examination is conducted to assess the current handling of information security within the dynamic landscape of change and transformation in public administration. This includes a nuanced exploration of the challenges and intricacies inherent in this evolving context.

Public administration plays a crucial role in shaping pro-safety organizational and individual behaviors in various types of organizations. This is related to the creation of formal and legal requirements and the adoption of substantive standards at various levels and dimensions of organizational functioning. This also includes infrastructure, which should meet reliability criteria in all its areas. Moreover, a concerted effort is made to foster a deeper understanding of the concerns and uncertainties that permeate decision-making processes in this specialized field. Unraveling the intricacies of these concerns is pivotal in crafting effective strategies and frameworks.

A fundamental aspect of this exploration involves identifying structural starting points and establishing a methodological framework (xmis) to facilitate access to the multifaceted domains of IT security, data protection, and compliance specifically tailored for organizational contexts. This endeavor seeks to bridge the gap between theoretical constructs and pragmatic applications.

An equally pressing question surfaces regarding the empowerment of business and government leaders, aiming to equip them with the capabilities to initiate and oversee compliance measures within the intricate fabric of their respective organizations. This involves not only understanding compliance but also instilling the tools and insights necessary to navigate its complexities.

Lastly, a forward-looking perspective is adopted in contemplating the future design of the empowerment concept for employees. The emphasis lies in crafting a framework that ensures the seamless integration and sustained application of an ISMS in the day-to-day operations of organizations

post-implementation. This forward-thinking approach recognizes the evolving nature of information security and seeks to embed its principles into the very fabric of organizational culture.

A multidimensional review of literature in the area of the concept of safety culture has shown that most models of safety culture are composed of many components. This component approach is consistent with approaches to constructing efficient and effective technical organizations.

Although the component structure is static in nature, its appropriate architecture allows for the generation of a range of proposals for improving technical organizations based on safety criteria. Furthermore, this relationship enables the development of decision-making processes based on specific cause-and-effect relationships between individual elements of safety culture. This reduces the margin for error in managing technical organizations. In such a cognitive space, components for shaping the safety culture of technical organizations have been identified. To this end, a group of safety culture models has been aggregated on the basis of bibliographic studies, which provide a platform for defining key components of the safety culture of technical organizations. A list of the key components of the safety culture of this type of organization has been selected therefrom (Table 2).

The list of key components of safety culture presented in the table provides an interesting potential for selecting those that form the basis for determining such components that may have a significant impact on the social impact of technical organizations.

When comparing the key characteristics of safety culture in a technical organization, one should critically consider their significance for safety culture and their social impact. In this context, it is important to note that technical and human factors are intertwined in almost every comparison of key safety culture components. However, they represent different approaches. On the one hand, they refer to elements of management and quality science, such as human and organizational behavior. On the other hand, they clearly point to the psychological conditioning of people in the organization, and on the other hand, they treat people as components of the technical system. This can result in potential discrepancies not only in the interpretation process but also, and above all, in the applicability of these solutions and their effectiveness and efficiency. Regardless of the adopted assumption, there is a noticeable cause-and-effect relationship between the social aspect and safety culture, which forms the basis for improving technical organizations. However, this connection is limited by the words and word groups describing this relationship, with varying, often contradictory, meanings, both in linguistic semantics and logic.

6 | Research Methodology

For the purpose of testing and verifying the assumptions made, the question was raised as to whether safety culture is the social impact of technical organizations.

TABLE 2 | Components of the safety culture of a technical organization (own study).

No.	Aggregated group of safety culture models, which provides a platform for defining key components of safety culture in technical organizations	List of key components of safety culture
1.	Areas of safety culture (Studenski 2000)	Individual safety culture, society security culture, business safety culture
2.	An iceberg as a metaphor for safety culture and climate (Graham 2008)	Values, perceptions, beliefs, leadership styles
3.	Cooper's occupational safety culture model (Cooper 2000)	Safety climate, safety management system, safety behavior
4.	Model of safety culture construction (Choudhry et al. 2007)	Safety climate, safety participation, increased safety knowledge, increased safety motivation, safety behavior, safety management system
5.	Conditions for the effective development of an occupational safety culture (Żurkowski 2015)	Open and sincere communication, cooperation between employees, employee participation, motivating and strengthening safe behavior, involvement of management, health and safety education, accidents, incidents and potential accident analysis
6.	Cox and Cox architecture of attitudes to safety (Cox and Cox 1991)	Attitudes to safety, hardware and physical hazards, software, people (liveware), risk
7.	Model of the impact of safety culture on behavior at work (Sharon 2000)	Working climate and perception, health and safety training, safe behavior, working climate, perception of management involvement, working climate and risk perception
8.	Glennon's organizational model (Glennon 1982)	Strategy, structure, processes, people, gambling, products, services, accidents, behaviors, individual outcomes
9.	Safety culture maturity model (Fleming and Joyner 2002)	Cooperating, constantly improving, developing management commitment, realizing the importance of frontline staff and developing personal responsibility, engaging all staff in developing cooperation and commitment to improving safety, developing consistency and fighting complacency
10.	Hudson's safety culture model (Hudson 2001)	We don't care as long as we're not caught; safety is important, we do a great deal every time we have an accident; we have systems in place to manage all risk; safety leadership and values drive our continuous improvement; safety is how we do everything round here
11.	Kopelman's safety culture model (Kopelman et al. 1990)	Societal culture, goal emphasis, means emphasis, reward orientation, task support, socio-emotional support, work motivation, job satisfaction, physical output, total labor costs
12.	Model of the impact of safety culture on the incidence of accidents and occupational diseases (Studenski 2000)	Quality of safety management, conditions, hazards, accidents, occupational diseases
13.	Eagly and Chaiken's attitude-behavior model (Eagly and Chaiken 1993)	Cognitive processes, affective processes, behavioral processes, cognitive responses, affective responses, behavioral responses
14.	Sequence of actions on occupational safety and health in a company (Ejdys 2010)	Improved working conditions, raising the level of culture, comparison of safety levels
15.	Human working environment in the context of safety culture (Ejdys 2010)	Motivation, workload, social responsibility, chemical pollution, microclimate, radiation, the need for safety, people, biological agents, vibrations, noise, lighting, hygiene and sanitary conditions, self-realization of an attitude, interpersonal relations, attitudes
16.	E.S. Geller's safety culture model (Ejdys 2010)	Physical environment, e.g., tools, machines, organization of workstations, individual features e.g., knowledge, skills, motivation, behavior of employees, e.g., compliance with health and safety regulations, information, cooperation, safety concern

(Continues)

TABLE 2 | (Continued)

Aggregated group of safety culture models, which provides a platform for defining key components of safety culture in technical organizations		List of key components of safety culture
No.		
17.	Berends' safety culture model (Berends 1995)	Norms (individual, interactional, organizational), beliefs (controllability of safety, controllability by the individual, causes of accidents, human nature, results of safe work, evaluation of the situation)
18.	Multi-directional safety culture assessment model (Cox and Cheyne 2000)	An objective organizational attribute, perceptions of the organization, individual perceptions
19.	Matrix of the OSH Culture Platform (Ejdys 2010)	Carelessness, authority, backwardness, ignorance
20.	Deming cycle (PDCA cycle) – continuous improvement scheme (Ishikawa 1985)	Plan, Do, Check, Act
21.	Safety-oriented area according to time (Hudson 2007)	Technology (engineering, equipment, safety, compliance), systems (integrating HSE (health, safety, environment), certification, competence, risk assessment), culture (behaviors, leadership, accountability, attitudes, HSE as a profit center)

In addition, the configuration of factors shaping the safety culture of technical organizations, including their interdependence and the ranking of importance, was verified.

The proposed analytical and research model was used to analyze the factors shaping safety culture in terms of their importance in the implementation of social impact. Organizational systemic structures are designed to consistently allocate resources towards enhancing cybersecurity. Beyond underscoring their importance and delineating pathways for implementation among decision-makers, fostering an environment that empowers employees to seamlessly integrate current business processes with a focus on IT compliance is crucial.

Efforts were made to make the most appropriate decision in choosing a suitable research method from among the heuristic methods and techniques requiring the analysis of available information, as well as predicting future phenomena based on creative thinking and logical combinations.

Therefore, Vester and AHP methods were selected.

A key assumption of the Vester method used in scientific research is the broad analysis of the influence of factors on the system, as well as the influence of the system on the factors. The measure of a given factor's influence on the system is the so-called active sum (AS), which is determined as the sum of the points in the row corresponding to the factor. The higher the value of the AS, the stronger the influence of the factor on the system, indicating its greater susceptibility to external influences. The strength of a given system's influence on a given factor is the so-called passive sum (PS), which is determined as the sum of the points in the column designated for the given factor. The higher the value of the PS, the stronger the system's influence on that factor. To determine the interdependencies between individual factors and the system, it is necessary to determine the so-called quotient and product. The quotient is a measure of the relationship

between the strength of a given factor's impact on the system and its susceptibility to the system's influence. It is determined for each factor by multiplying the AS determined for the given factor by 100 and dividing the result by the PS of the given factor. This product, in turn, measures the factor's importance in the system being studied. Determining the product for a given factor involves multiplying its AS by its PS. If the AS is greater than 100 points, it indicates that the studied factor affects the system more strongly than the system affects it. A high value of the product for a given factor indicates its significant importance in the system, and vice versa. Calculations performed during the research process enable their graphical presentation. In terms of graphical visualization of calculation results, an additional division of factors was used into those with a quotient greater than 100 and less than 100 points, and those with the highest and small or average product. The boundaries between these intervals on the graph are, in the first case, a straight line starting at the origin and symmetrically dividing the coordinate system, and in the second case, a curve based on the points determined by the factors with the largest and smallest PSs. The final stage of Vester's analysis is the graphical development of the interaction analysis, which consists of the following:

1. Establishing a network of relationships between factors.
2. Analyzing the quality of the existing relationships.
3. Analyzing the dynamics of the interactions and their changes over time.
4. Analyzing existing feedback loops.

The result of this analysis is the creation of a graph of relationships for those relationships with high impact. The Vester method used is qualitative in nature.

The Vester method was used to assess the impact of defined individual factors of safety culture on its overall form and the impact of this safety culture on individual factors.

In turn, the AHP method allowed for the determination of a ranking of factors that shape the safety culture of a technical organization.

The AHP method is a hierarchical problem analysis method (AHP) developed by the American scientist T.L. Saaty in 1970. This method is constantly being modified and refined. It primarily serves to support the selection of appropriate decision-making options. Such options can be various types of objects (e.g., machines, products) or specific design or process options leading to the achievement of specific outcome states (safety, quality, risk). The AHP method assumes:

- a multi-criteria approach that balances the trend-forming procedure and provides comparable options,
- the characterization of psychological evaluation processes, which are relational and hierarchical.

The possible outcomes of the studied options are linked to a given assessment based on experience, which directly relates to their impact on achieving a specific overarching goal. The overarching goal is the most general culmination of a hierarchical decision-making structure. It should be pursued by meeting the main goals, which are composed of sub-goals (auxiliary goals). The AHP method is primarily used when:

- specific criteria for evaluating alternatives demonstrate varying levels of detail,
- there is a hierarchy of criteria for evaluating alternatives,
- the criteria for evaluating alternatives are predominantly qualitative,
- the evaluator participating in the study tends to be subjective in their assessments,
- the identified alternatives can be compared,
- decision-making situations present varying levels of risk of failure (e.g., in employment evaluation, performance forecasting, cost/benefit analysis, quality management, production management, strategy formulation, planning).

The individual stages of the AHP analysis are as follows:

1. Construction of an appropriate hierarchical model—representing a given decision problem as individual levels of the hierarchy:
 - a. Primary goal—the highest, achieved level of the hierarchy,
 - b. Decision criteria or other factors—intermediate levels influencing the degree of achievement of the primary goal; the number of levels depends on the scale and complexity of the problem.
 - c. Decision alternatives—the lowest level of the hierarchy.
2. Evaluation by pairwise comparison—elements at each level of the hierarchical model are compared with the related element from the higher level.
3. Determining global preferences (selection criteria) and local preferences (decision options under consideration) and determining their mutual importance.

4. Ranking specific decision options, taking into account their contribution to achieving the overarching goal.

Decision options at the lowest level of the model hierarchy are subject to comparative evaluation. Individual criteria are compared in pairs, and their degree of fulfillment is assessed. This comparative evaluation, taking into account the achieved relative scores, leads to the presentation of the decision-maker's local preference matrix. The result is the determination of a vector resulting from the ordering of options based on the degree of fulfillment of the assumed goal.

In the process of comparing criteria and options, a specific measurement scale, called the fundamental Saaty scale, is used. The final step of the analysis is the construction of a hierarchical composition of the priorities of the criteria and decision options, that is, obtaining a solution to the given decision problem.

With data on the value of a given criterion for each decision option, all weightings can be calculated.

The Vester method and the AHP method are mutually reinforcing, but not complementary. This means that by combining research using these two methods, multidimensional final data can be obtained, which can lead to a complex system of inferences and the definition of a range of strategic recommendations in decision-making processes. The research methodology adopted in this research study was properly validated, meaning that the results are scientifically reliable and credible.

7 | The Results of Research

7.1 | Vester

Goal of the Analysis: The goal of the analysis is to identify key factors of the process of shaping safety culture in order to identify such factors that are essential for the effectiveness and success of the safety culture in question.

Scope of Analysis: The scope of the analysis includes selected, representative components of the process of shaping the safety culture of a technical organization, which will be used to identify core components and enable core factors to be identified through the chosen method.

Subject of Analysis: The subject of the analysis is to identify the factors of the process of shaping safety culture and defining their interdependence in order to identify factors that may increase the efficiency of the process of shaping safety culture.

F. Vester's method (Vester 1975, 1976, 1978, 1984, 1988, 1989) of complex problem solving was used to identify risk factors.

The key stages of this method are:

1. Defining the problem and its elements.
2. Impact analysis.

3. Explanation of the possibilities of impact.

In the first step of this method, it is necessary to make a list of factors that have the greatest impact on a given problem. Therefore, selected factors were defined that have a significant impact on the components of the safety culture of a technical organization:

1. Results of accidents, incidents and potential accidents
2. Authority
3. Individual features, for example, knowledge, skills, and motivation
4. Health and safety education
5. Quality of safety management
6. Working climate and risk perception
7. Competence
8. Societal culture
9. People's attitudes
10. Norms (individual, interactional, organizational)
11. Workload
12. Open and sincere communication
13. Employee participation
14. Socio-emotional support
15. Working conditions
16. Employees' knowledge of safety
17. Sensing the involvement of management
18. Need for safety
19. Behavioral processes
20. Cognitive processes
21. Behavioral responses
22. Interpersonal relations
23. Self-realization
24. Satisfaction with safety
25. Social responsibility at work
26. Strategy
27. Structure
28. Leadership styles
29. Safety management system
30. Physical environment, for example, tools, machinery, or organization of workstations
31. Values
32. Hygiene and sanitary conditions
33. Cooperation between employees
34. Involvement of management

This method is based on the assumption that not only do factors affect the system examined, but the environment of the system also affects the factors examined.

The next step is to determine the direct impact between the defined elements. The way to implement this stage is to create a matrix and determine the force of 0 and 3 of one factor on the other, where 0 means no impact and 3 means that one factor has a very strong impact on another. The results of this analysis are presented in Table 3.

The assumption of the Vester method is to analyze the impact of factors on the system as well as the system on factors. The measure of the impact of a given factor on the system is the so-called AS, determined as the sum of the points of the row corresponding to the given factor. The higher the value of the AS, the stronger the factor affects the system, and at the same time it means that the factor is more susceptible to external impacts. In this area of the problem, this will be the AS of the impact of the process components of shaping the safety culture of a technical organization. The measure of the system's impact on a given factor is called the PS, which is determined as the sum of points in the column for a given factor. The higher the value of the PS, the stronger the impact of the system on this factor. Thus, in the case discussed, it describes the impact of the efficiency of shaping safety culture on factors, which arise during its implementation. It will also indicate which factors in this situation can be good early warning indicators against loss of expected efficiency. For these sums and for each factor, two subsets must be created. The first one should contain factors with low impact (below the arithmetic mean of the sum), and the second set must contain factors that are more susceptible to the system. Table 4 shows active and passive factors.

In order to determine the interdependence between the various factors and the system, the quotient and product should be determined. The quotient is a measure of the relationship between the force of a factor's impact on the system and its susceptibility to the system impact and is determined for each factor by multiplying the AS determined for a given factor by 100 and dividing the result by the PS of the factor. The product, in turn, is a measure of the importance of the factor in the system. The product of a given factor is determined by multiplying its AS by the PS of this factor. If the quotient is greater than 100 points, it means that the factor examined acts on the system with more force than when the system acts on it. The high value of the product of a given factor functions as information about its importance in the system and vice versa. After ordering the increasing product values and dividing 34 factors into three groups (by the number of factors), a percentage of the products was created. Table 5 presents the results of the quotient and product calculations for factors.

The calculations allow them to be graphically presented. In terms of the graphical visualization of the results of the calculation, the additional division of factors into those with a quotient of greater than 100 and less than 100 points and those which have the highest, average or smallest product is undertaken. The boundaries between these intervals on the graph are, in the first case, a line starting at the beginning of the coordinate system and dividing the coordinate system

TABLE 3 | The matrix of impact after applying the force of impact (own study).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	AS		
1	X	0	0	0	3	3	2	3	0	0	0	0	0	2	3	0	3	0	3	0	0	0	0	0	2	3	0	0	3	2	0	0	3	3	35		
2	0	X	2	0	3	3	0	3	3	0	3	3	0	2	2	3	0	3	0	3	3	3	3	3	3	3	2	3	2	0	3	0	3	3	70		
3	0	2	X	3	3	3	2	2	3	2	0	3	2	0	0	2	2	3	3	3	3	3	3	2	2	2	2	0	2	0	3	0	3	0	63		
4	3	0	0	X	3	3	0	2	3	0	3	3	0	2	3	3	3	2	2	2	2	2	2	3	3	2	2	0	3	3	0	0	3	2	61		
5	0	2	0	0	X	2	0	2	2	0	0	3	2	0	3	2	2	0	3	2	2	2	0	0	3	3	3	2	0	3	0	2	0	2	2	47	
6	0	2	0	0	2	X	0	2	3	0	0	3	2	0	3	2	3	3	3	2	2	3	2	2	3	2	2	3	0	3	0	0	0	0	53		
7	2	3	2	3	3	3	X	2	2	2	0	2	3	0	0	3	2	2	2	2	2	2	2	3	0	2	3	2	0	2	0	2	0	3	3	62	
8	0	3	2	2	2	2	2	X	3	2	0	3	3	3	3	3	2	3	0	2	2	0	2	2	3	3	3	2	0	3	0	3	0	3	3	67	
9	0	3	3	3	2	3	2	3	X	2	0	3	3	2	2	2	3	3	3	3	3	3	2	3	2	2	2	2	3	2	3	0	3	0	3	81	
10	0	0	2	3	3	3	2	2	2	X	2	2	3	0	3	0	0	0	2	2	2	2	0	2	3	0	3	0	0	3	0	3	0	3	2	51	
11	3	0	0	0	0	3	0	0	3	2	X	0	0	0	3	0	0	3	3	2	3	0	0	3	2	2	2	2	0	3	2	0	3	0	45		
12	0	0	0	0	0	3	2	3	3	2	0	X	2	0	0	2	3	2	2	2	3	2	3	0	2	2	2	2	3	2	0	3	0	3	3	54	
13	3	0	2	0	2	2	3	3	3	3	3	2	X	0	3	0	0	2	2	2	3	3	3	2	3	2	2	2	2	2	2	0	3	2	67		
14	0	0	0	0	0	3	0	3	3	3	3	0	0	X	2	0	3	2	2	2	2	2	0	3	2	3	2	3	0	3	2	3	2	3	2	56	
15	2	2	0	2	3	3	0	3	3	3	3	0	2	X	0	3	3	3	3	2	3	0	0	3	2	2	2	2	0	3	2	3	0	2	65		
16	3	2	2	3	2	2	3	3	2	3	0	2	3	0	3	X	3	3	2	2	2	2	2	3	2	3	2	2	2	3	2	3	2	3	2	76	
17	0	3	2	0	2	3	2	2	2	3	0	3	3	0	0	0	X	3	3	3	2	2	0	3	3	0	3	0	0	2	0	2	0	0	3	51	
18	3	2	3	2	3	3	2	3	3	3	3	2	2	2	3	3	3	X	2	2	2	3	3	3	2	2	2	2	2	3	3	3	3	3	86		
19	3	3	3	2	3	3	2	3	3	2	3	2	2	2	3	2	3	2	X	2	3	2	2	2	3	2	2	2	3	2	2	2	2	3	2	80	
20	3	2	3	2	2	2	2	2	3	2	2	3	3	2	2	2	2	3	2	2	X	3	3	2	2	2	2	2	3	2	3	2	3	2	3	2	78
21	3	3	3	2	2	3	2	3	3	2	3	2	3	2	3	2	2	3	3	3	3	X	3	2	2	2	2	2	3	2	3	3	2	3	2	84	
22	3	3	3	2	3	2	2	3	2	3	3	3	3	2	3	2	2	3	2	2	3	3	X	2	2	2	2	2	3	2	3	3	3	3	3	84	
23	0	3	3	2	3	2	3	2	2	3	0	3	3	0	3	2	3	3	2	2	2	2	2	X	2	2	0	0	2	3	3	0	3	3	3	66	
24	3	3	2	3	3	3	3	3	3	2	3	2	2	3	3	3	3	3	2	2	2	2	2	2	X	2	3	2	2	3	3	3	2	2	2	84	
25	2	2	2	0	0	3	2	3	3	3	2	2	3	2	2	2	3	2	3	2	2	2	2	2	2	X	2	2	3	2	2	3	3	2	3	73	
26	3	2	2	2	3	2	3	3	2	3	2	2	3	2	3	3	3	3	2	2	2	2	2	3	3	2	X	3	3	3	3	2	3	3	3	83	
27	3	2	0	2	2	2	0	2	2	3	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	2	3	2	2	3	0	3	2	0	66		
28	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	2	3	3	3	3	2	3	3	3	X	2	3	3	3	3	3	94	
29	3	2	2	3	3	3	2	3	3	3	3	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	79	

(Continues)

TABLE 3 | (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	AS
30	2	0	3	0	3	3	3	3	2	3	2	3	2	0	3	0	3	3	2	0	2	0	0	0	0	0	0	0	3	X	0	3	3	3	56
31	3	2	3	3	2	3	2	3	3	3	3	3	2	2	2	2	2	3	2	2	3	3	3	3	3	3	2	3	2	3	X	3	2	2	85
32	3	0	0	0	3	3	0	3	3	3	3	0	0	3	3	0	0	3	0	0	0	0	0	0	0	0	0	0	3	3	0	X	0	0	36
33	0	0	0	0	2	3	0	3	3	0	0	3	3	0	0	0	3	0	2	3	2	3	3	2	2	2	2	3	2	0	2	0	X	2	50
34	0	3	0	2	2	3	3	3	3	2	0	3	2	2	2	2	3	0	2	2	3	3	3	2	3	3	2	3	2	0	2	3	2	X	70
FVCS	56	57	52	49	75	90	54	85	87	72	48	75	70	41	73	55	76	72	71	70	75	66	57	72	77	69	54	54	76	62	66	54	77	71	

symmetrically; and, in the second case, the curve based on the points determined by the factors with the largest and lowest PSs. Figure 2 presents grouped risk factors. The most important group of factors isolated in this way by the importance for the system is those in the right upper quadrant of the graph located behind the product line. In this example, most factors are critical. A change of critical parameters also shows a large impact on the system, but as they are influenced by a significant number of other parameters, it is harder to predict their changes and therefore their impact on the entire system. These factors have the greatest impact on the process of shaping the safety culture of a technical organization. If a parameter influences more relevant parameters among the system parameters, it should be categorized as “active” or “critical” rather than such parameters which influence less relevant parameters.

On the basis of this analysis, using Vester’s analysis, it is possible to identify those factors which, in terms of their complexity and interrelationships, have the greatest impact on the efficiency of the development of safety culture.

It is important to note that, in the context of the Vester method, this method has several significant limitations. The first is the subjective nature of the assessment, as participants in the research process assess the impact of individual factors based on their own feelings, knowledge, and experiences. Furthermore, there is a lack of objective measures, which can lead to erroneous or biased conclusions and, consequently, to related strategic recommendations. A significant limitation is the complexity associated with a large number of factors being verified. When analyzing multiple factors (e.g., more than 10–15), the correlation matrix becomes very unclear and difficult to interpret. This requires significant focus and time. Applying this method also requires a dedicated, trained, and competent moderator with extensive knowledge of the method. Without proper scientific research, the process can become chaotic, ineffective, or heavily dominated by individuals. Quantitative limitations also play a role. The influence matrix works best in specific, smaller groups (up to a dozen or so people). With larger numbers of participants, achieving mutual consensus is difficult. This is not suitable for very large data sets. Furthermore, Vester’s method does not account for temporal dynamics. The analysis of dependencies is static in nature and does not show how specific factors may change over time. The risk of oversimplification is also significant. The need to reduce complex phenomena to single factors and their influences can lead to overgeneralization of the analysis. There were two active factors: health and safety education (4.) and socio-emotional support (14.). They are characterized by the highest impact on safety culture.

There is only one buffering factor—workload (11.), which means that it has a slight impact on safety culture and little flexibility in relation to this culture.

In Vester’s model, the buffering coefficient (also called the inhibition coefficient) is a key element used primarily to understand the resilience of a given system element within a specific network of interdependencies. The buffering coefficient quantifies the degree to which a designated element is influenced by other

TABLE 4 | Profile of factors constituting the active sum and the passive sum (own study).

No.	Factors	Active sum			Passive sum		
		Low	High		Low	High	
		Impact			Impact		
		0	51	102	0	51	102
1.	Results of accidents, incidents and potential accidents	35					56
2.	Authority			70			57
3.	Individual features, e.g., knowledge, skills, motivation			63			52
4.	Health and safety education			61	49		
5.	Quality of safety management	47					75
6.	Working climate and risk perception			53			90
7.	Competence			62			54
8.	Societal culture			67			85
9.	People's attitudes			81			87
10.	Norms (individual, interactional, organizational)			51			72
11.	Workload	45					48
12.	Open and sincere communication			54			75
13.	Employee participation			67			70
14.	Socio-emotional support			56	41		
15.	Working conditions			65			73
16.	Employees' knowledge of safety			76			55
17.	Sensing the involvement of management	51					76
18.	Need for safety			86			72
19.	Behavioral processes			80			71
20.	Cognitive processes			78			70
21.	Behavioral responses			84			75
22.	Interpersonal relations			84			66
23.	Self-realization			66			57
24.	Satisfaction with safety			84			72
25.	Social responsibility at work			73			77
26.	Strategy			83			69
27.	Structure			66			54
28.	Leadership styles			94			54
29.	Safety management system			79			76
30.	Physical environment, e.g., tools, machinery, organization of workstations			56			62
31.	Values			85			66
32.	Hygiene and sanitary conditions	36					54
33.	Cooperation between employees			50			77
34.	Involvement of management			70			71

TABLE 5 | Calculation of the quotient and product for factors (own study).

No.	Factors	Quotient		Product		
		Low	High	low 33%	33%	High 33%
		< 100	≥ 100			
1.	Results of accidents, incidents and potential accidents	63		1960		
2.	Authority		123		3990	
3.	Individual features, e.g., knowledge, skills, motivation		121		3276	
4.	Health and safety education		124		2989	
5.	Quality of safety management	63			3525	
6.	Working climate and risk perception	59				4770
7.	Competence		115		3348	
8.	Societal culture	79				5695
9.	People's attitudes	93				7047
10.	Norms (individual, interactional, organizational)	71			3672	
11.	Workload	94		2160		
12.	Open and sincere communication	72			4050	
13.	Employee participation	96			4690	
14.	Socio-emotional support		137	2296		
15.	Working conditions	89				4745
16.	Employees' knowledge of safety		138		4180	
17.	Sensing the involvement of management	67			3876	
18.	Need for safety		119			6192
19.	Behavioral processes		113			5680
20.	Cognitive processes		111			5460
21.	Behavioral responses		112			6300
22.	Interpersonal relations		127			5544
23.	Self-realization		116		3762	
24.	Satisfaction with safety		117			6048
25.	Social responsibility at work	95				5621
26.	Strategy		120			5727
27.	Structure		122		3564	
28.	Leadership styles		174			5076
29.	Safety management system		104			6004
30.	Physical environment, e.g., tools, machinery, organization of workstations	90			3472	
31.	Values		129			5610
32.	Hygiene and sanitary conditions	67		1944		
33.	Cooperation between employees	65			3850	
34.	Involvement of management	99				4970

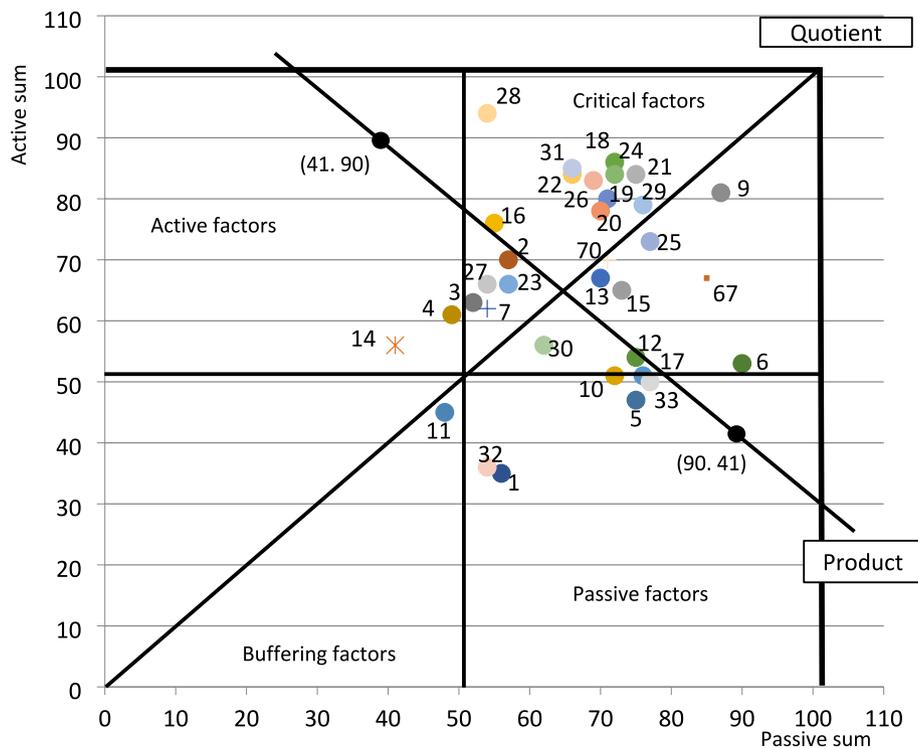


FIGURE 2 | A matrix of factors (own study).

elements relative to its influence on others. It indicates how stable or vulnerable an element is within the system. In practice, we use a high buffering coefficient when protection or stabilization is required (e.g., fragile environmental or social systems) and a low buffering coefficient when pressure points are targeted for specific interventions (e.g., economic factors). Passive factors have little impact on safety culture and are influenced by safety culture. They include: results of accidents, incidents, and potential accidents (1.), quality of safety management (5.) and hygiene and sanitary conditions (32.).

Other factors are critical, which means that they have a strong impact on the safety culture in which they function and are also significantly susceptible to it, because their actions pose a threat of uncontrolled feedback. The most influential factors are as follows: the need for security (18.), behavioral processes (19.), cognitive processes (20.), behavioral reactions (21.), interpersonal relationships (22.), satisfaction with safety (24.), strategy (26.), security management system (29.) and values (31.).

The most active factor that influences safety culture and at the same time has an average value of culture impact on this factor, which is a critical factor, is leadership styles (28.).

However, overlapping parameters should also be addressed within the limits of their respective affiliation. Such an analysis for the factors of shaping safety culture should identify safety culture and serve its development to increase the efficiency of shaping this culture and provide a basis for further discussion. The qualitative method used should be used in an effective way.

The above graph (Figure 3) shows strong relationships (those that received a value of three in both directions, i.e., both factors interact strongly with each other) between the factors

mentioned above. In addition, active, critical, and passive factors are indicated by circles, squares, and triangles respectively. The buffering factor was shown without the geometric figure.

7.2 | AHP

The Analytic Hierarchy Process (AHP) method was developed by American scholar T.L. Saaty in 1970. The method is still being modified and is used mainly to support decision-making. The analysis compares several issues:

1. Results of accidents, incidents and potential accidents
2. Authority
3. Individual features, for example, knowledge, skills, motivation
4. Health and safety education
5. Quality of safety management
6. Working climate and risk perception
7. Competence
8. Societal culture
9. People's attitudes
10. Norms (individual, interactional, organizational)
11. Workload
12. Open and sincere communication
13. Employee participation
14. Socio-emotional support

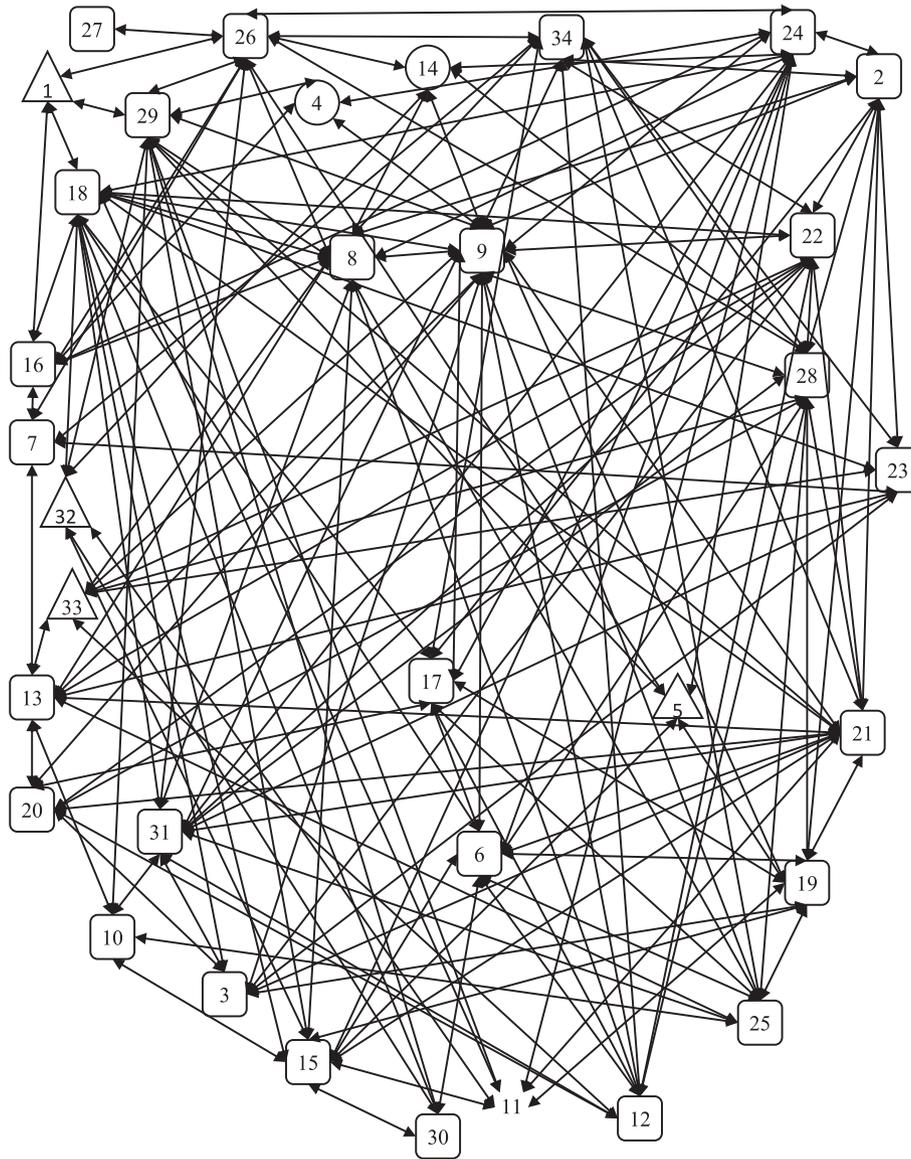


FIGURE 3 | Graph of the relationship of risk factors taking into account the strong influence of factors (own study).

- 15. Working conditions
- 16. Employees' knowledge of safety
- 17. Sensing the involvement of management
- 18. Need for security
- 19. Behavioral processes
- 20. Cognitive processes
- 21. Behavioral responses
- 22. Interpersonal relations
- 23. Self-realization
- 24. Satisfaction with safety
- 25. Social responsibility at work
- 26. Strategy
- 27. Structure
- 28. Leadership styles

TABLE 6 | Saaty's scale used to compare criteria in pairs (own study based on Saaty 1987).

Significance scale	Explanation
1	No criterion has an advantage over the other in achieving the goal.
3	Criterion A has a moderate advantage over option B.
5	Criterion A has a strong advantage over option B.

- 29. Safety management system
- 30. Physical environment, for example, tools, machinery, organization of workstations
- 31. Values
- 32. Hygiene and sanitary conditions
- 33. Cooperation between employees

TABLE 7 | Matrix showing pairwise comparisons for particular criteria (own study).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34			
1	1.00	0.20	0.33	0.33	0.20	0.20	0.33	0.20	0.20	1.00	0.20	0.20	0.20	1.00	1.00	1.00	0.20	0.20	0.33	0.33	0.20	0.20	0.33	0.33	0.20	0.33	0.20	0.33	0.20	0.33	0.20	0.33	0.33	0.20			
2	5.00	1.00	5.00	3.00	1.00	1.00	3.00	1.00	1.00	3.00	1.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	3.00	3.00	1.00	3.00	1.00	1.00			
3	3.00	0.20	1.00	3.00	1.00	1.00	3.00	0.33	3.00	0.33	1.00	0.33	1.00	1.00	1.00	1.00	0.33	0.33	1.00	1.00	0.33	0.33	0.33	0.33	0.33	0.33	3.00	0.20	0.33	1.00	1.00	3.00	0.33	0.20			
4	3.00	0.33	1.00	3.00	0.20	1.00	3.00	0.33	1.00	0.33	0.33	0.33	0.33	1.00	1.00	0.33	0.20	0.20	0.33	0.33	0.33	0.33	0.20	0.33	0.33	0.33	1.00	1.00	0.20	0.33	1.00	0.20	1.00	0.33	0.20		
5	5.00	1.00	1.00	3.00	1.00	0.20	1.00	0.20	0.33	1.00	0.33	0.20	0.20	0.33	0.33	0.33	0.20	0.20	0.33	1.00	0.33	0.20	0.20	0.33	0.33	0.33	1.00	1.00	0.20	0.33	1.00	0.20	1.00	0.33	0.20		
6	5.00	1.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	3.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	3.00	5.00	0.33	3.00	3.00	3.00	1.00	0.33			
7	3.00	0.33	1.00	1.00	1.00	0.33	1.00	0.20	1.00	0.20	0.20	0.20	0.20	1.00	0.33	1.00	0.20	0.20	0.33	0.20	0.33	0.20	0.20	0.33	0.33	0.33	3.00	1.00	0.20	0.33	1.00	0.20	1.00	0.33	0.20		
8	5.00	1.00	3.00	3.00	5.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	3.00	3.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	0.33	3.00	0.33	3.00	0.33	3.00	1.00	1.00		
9	5.00	1.00	3.00	3.00	3.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	1.00	3.00	1.00	3.00	1.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	0.33	3.00	0.33	3.00	1.00	3.00	1.00	1.00	
10	1.00	0.33	0.33	1.00	1.00	0.33	1.00	0.33	1.00	0.20	0.20	0.20	0.20	1.00	1.00	1.00	0.20	0.20	0.33	0.33	0.33	0.20	0.20	0.33	0.33	0.33	0.20	0.33	0.20	0.33	1.00	0.20	1.00	0.33	0.20		
11	5.00	1.00	3.00	3.00	3.00	1.00	5.00	1.00	1.00	5.00	1.00	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	0.33	0.33	1.00	0.20	0.33	1.00	0.20	0.33	1.00	0.20	1.00	0.20	0.20		
12	5.00	1.00	3.00	3.00	5.00	1.00	5.00	1.00	1.00	5.00	3.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	0.33	1.00	3.00	3.00	1.00	3.00	1.00	1.00	
13	5.00	1.00	1.00	3.00	5.00	1.00	5.00	1.00	1.00	5.00	3.00	1.00	1.00	3.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	0.33	3.00	0.33	1.00	3.00	0.33	1.00	1.00	
14	1.00	0.33	1.00	1.00	1.00	0.33	1.00	1.00	0.33	1.00	0.33	0.33	0.33	1.00	0.33	1.00	0.33	1.00	1.00	1.00	1.00	0.33	0.20	0.33	0.20	0.33	0.33	0.20	0.33	1.00	0.20	1.00	0.33	0.33	0.33		
15	1.00	0.33	1.00	1.00	3.00	1.00	3.00	1.00	1.00	3.00	1.00	0.33	1.00	3.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
16	1.00	1.00	1.00	3.00	3.00	1.00	1.00	0.33	1.00	0.33	1.00	1.00	0.33	1.00	0.33	1.00	0.33	0.33	1.00	1.00	1.00	0.33	0.33	0.33	0.33	0.33	0.20	0.33	0.20	0.33	1.00	0.20	1.00	0.33	0.20		
17	5.00	1.00	3.00	5.00	5.00	1.00	5.00	3.00	1.00	5.00	3.00	1.00	1.00	3.00	1.00	3.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
18	5.00	1.00	3.00	5.00	5.00	1.00	5.00	1.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	3.00	1.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	
19	3.00	0.33	1.00	3.00	3.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
20	3.00	0.33	1.00	3.00	1.00	0.33	3.00	1.00	0.33	3.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
21	3.00	0.33	1.00	3.00	3.00	1.00	5.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	1.00	1.00	1.00	3.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
22	5.00	1.00	3.00	3.00	5.00	1.00	5.00	1.00	1.00	5.00	3.00	1.00	1.00	1.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
23	5.00	1.00	3.00	5.00	5.00	1.00	5.00	1.00	1.00	5.00	3.00	1.00	1.00	3.00	0.33	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
24	3.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	3.00	1.00	1.00	1.00	5.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
25	3.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	3.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	1.00
26	5.00	1.00	0.33	1.00	1.00	0.33	3.00	0.33	3.00	5.00	5.00	1.00	3.00	3.00	1.00	5.00	1.00	0.33	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
27	3.00	0.33	0.33	1.00	1.00	0.20	1.00	0.33	1.00	3.00	3.00	0.33	0.33	3.00	1.00	3.00	0.33	0.33	1.00	1.00	1.00	0.33	0.33	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
28	5.00	1.00	5.00	5.00	5.00	3.00	5.00	3.00	1.00	5.00	5.00	3.00	3.00	5.00	1.00	5.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
29	3.00	0.33	3.00	3.00	3.00	0.33	3.00	3.00	3.00	3.00	3.00	1.00	1.00	3.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

(Continues)

TABLE 7 | (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
30	3.00	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	1.00	0.33	1.00	1.00	0.33	0.33	1.00	0.33	1.00	0.33	1.00	0.33	1.00	0.33	1.00	0.33	0.33	0.33
31	5.00	1.00	1.00	5.00	5.00	0.33	5.00	3.00	1.00	5.00	5.00	1.00	3.00	5.00	1.00	5.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	3.00	1.00	5.00	1.00	1.00	1.00
32	3.00	0.33	0.33	1.00	1.00	0.33	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	0.33	1.00	1.00	0.33	0.33	1.00	0.33	1.00	0.33	1.00	0.20	1.00	0.33	0.33	0.33	0.33	0.33
33	3.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	5.00	1.00	1.00	3.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00
34	5.00	1.00	5.00	5.00	5.00	3.00	5.00	1.00	1.00	5.00	5.00	1.00	1.00	3.00	1.00	5.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00

34. Involvement of management

The above criteria were compared in pairs and their degree of fulfillment was considered. The criteria were compared in pairs using the following scale (Table 6):

7.3 | Determination of Weights for the Criteria Specified

Using the Saaty scale, a matrix of pairwise comparisons for the adopted criteria was constructed. An $n \times n$ matrix was made, where n stands for the number of criteria. In this case, $n = 8$, because eight criteria were adopted. The matrix represents the predominance of one criterion over the other, and the final comparison resulted in arranging the criteria in terms of final weights.

It should also be noted that there is a reversal of the assessments in the AHP method. This means that the matrix is consistent in pairs, that is,

$$w_{ij} \cdot \frac{1}{w_{ji}} = 1$$

The following is a matrix of pairwise comparisons for criteria (Table 7):

The above matrix of rankings was normalized by dividing individual ratings from the criteria (in columns) by the sum of the ratings of a given criterion (sum of the column ratings) and the matrix W was obtained (Table 8). In the further part of the analysis, the names of the criteria were shortened in order to transparency in the tables. With a normalized matrix, the values of each row are summed up. The values obtained were divided by the number of existing criteria (i.e., number 34), resulting in weights for each criterion:

The weights obtained are ranked from the highest to the lowest values, which are then shown in Table 9:

Therefore, the most important criteria in the analysis are “Need for safety” with a weight of 6.30% and “Leadership styles” with 5.42%. The lowest weight was obtained by the criterion “Results of accidents, incidents and potential accidents” with a weight of 0.82%.

8 | Discussion—Theoretical Implications

Based on the literature review and analytical studies based on qualitative research by means of Vester and AHP methods, the relationship between shaping safety culture and the social impact of technical organizations was assessed. The research is very important, especially from the perspective of the place and role of safety. Safety is regarded as a social good that ensures, within the scope of the processes in a technical organization, the life and health of employees and other outsiders affected by the organization. As we function among a number of different technical systems that affect the existence of people in the ecosystem, safety culture shaped by technical

TABLE 8 | Normalized matrix of pairwise comparisons and weights obtained for particular criteria (own study).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Weight		
1	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
2	0.08	0.03	0.01	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.03	0.04	0.09	0.01	0.04	0.06	0.09	0.07	0.08	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.08	0.05	0.04	0.05	0.04	0.04	0.08	0.03	0.04	
3	0.02	0.03	0.01	0.03	0.01	0.01	0.01	0.03	0.01	0.01	0.03	0.01	0.03	0.01	0.01	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.08	0.05	0.01	0.02	0.04	0.05	0.01	0.01	0.02	0.03	0.02	0.02	
4	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
5	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.03	0.01	0.01	
6	0.02	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.03	0.04	0.03	0.01	0.04	0.06	0.03	0.07	0.03	0.03	0.03	0.04	0.04	0.03	0.08	0.08	0.02	0.08	0.05	0.11	0.05	0.04	0.01	0.02	0.05	0.04	
7	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	
8	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03	0.02	0.04	0.03	0.01	0.03	0.04	0.01	0.06	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.08	0.05	0.02	0.01	0.05	0.01	0.05	0.04	0.04	0.05	0.03	0.03	0.03	
9	0.05	0.03	0.03	0.03	0.05	0.03	0.03	0.03	0.02	0.04	0.03	0.04	0.03	0.04	0.04	0.06	0.03	0.07	0.03	0.03	0.04	0.04	0.03	0.01	0.02	0.02	0.01	0.05	0.04	0.05	0.04	0.04	0.05	0.03	0.03	0.03	
10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
11	0.05	0.03	0.03	0.03	0.05	0.03	0.03	0.05	0.02	0.01	0.01	0.01	0.03	0.01	0.04	0.06	0.03	0.02	0.03	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.05	0.03	0.02	
12	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.05	0.04	0.03	0.04	0.04	0.09	0.01	0.04	0.06	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.05	0.02	0.03	0.05	0.04	0.05	0.04	0.05	0.03	0.04	0.04	
13	0.02	0.03	0.05	0.03	0.05	0.03	0.03	0.05	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.01	0.05	0.02	0.03	0.05	0.01	0.02	0.04	0.04	0.02	0.03	0.03	0.03	
14	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.03	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01	
15	0.02	0.01	0.03	0.03	0.03	0.03	0.03	0.01	0.02	0.01	0.03	0.04	0.03	0.04	0.04	0.06	0.03	0.02	0.03	0.03	0.11	0.04	0.03	0.03	0.02	0.05	0.03	0.02	0.04	0.02	0.04	0.04	0.02	0.01	0.03	0.03	
16	0.02	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.02	0.04	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.03	0.02	
17	0.05	0.05	0.05	0.03	0.05	0.09	0.03	0.05	0.02	0.04	0.03	0.04	0.03	0.04	0.04	0.06	0.03	0.07	0.03	0.03	0.04	0.04	0.03	0.03	0.05	0.05	0.03	0.02	0.04	0.02	0.04	0.04	0.05	0.05	0.04	0.04	
18	0.05	0.05	0.05	0.03	0.05	0.03	0.03	0.05	0.02	0.04	0.09	0.01	0.03	0.04	0.04	0.06	0.09	0.07	0.08	0.09	0.11	0.11	0.09	0.08	0.05	0.14	0.08	0.05	0.11	0.05	0.11	0.11	0.05	0.05	0.06	0.06	
19	0.02	0.03	0.03	0.03	0.05	0.03	0.03	0.03	0.02	0.04	0.03	0.01	0.03	0.01	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.05	0.03	0.02	0.04	0.02	0.04	0.04	0.02	0.03	0.03	0.03
20	0.02	0.03	0.01	0.01	0.03	0.03	0.01	0.03	0.02	0.04	0.03	0.01	0.03	0.01	0.01	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.05	0.03	0.02	0.04	0.02	0.04	0.04	0.02	0.03	0.02	0.02
21	0.02	0.03	0.03	0.03	0.05	0.03	0.03	0.03	0.02	0.04	0.03	0.01	0.03	0.01	0.04	0.02	0.03	0.02	0.03	0.02	0.01	0.04	0.03	0.03	0.02	0.05	0.03	0.02	0.04	0.02	0.04	0.04	0.02	0.03	0.03	0.03	0.03
22	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.05	0.04	0.03	0.01	0.03	0.04	0.01	0.04	0.02	0.03	0.02	0.01	0.03	0.04	0.04	0.03	0.01	0.05	0.02	0.03	0.05	0.04	0.05	0.04	0.04	0.05	0.03	0.03	0.03	
23	0.05	0.05	0.05	0.03	0.05	0.03	0.03	0.05	0.04	0.03	0.04	0.01	0.04	0.01	0.04	0.02	0.03	0.02	0.03	0.02	0.08	0.03	0.04	0.03	0.03	0.05	0.08	0.05	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04	
24	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.04	0.03	0.07	0.03	0.04	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.05	0.03	0.05	0.04	0.02	0.04	0.04	0.05	0.03	0.03	0.03	
25	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.03	0.04	0.03	0.04	0.04	0.02	0.03	0.02	0.03	0.02	0.03	0.04	0.03	0.03	0.02	0.05	0.03	0.02	0.04	0.02	0.01	0.04	0.05	0.03	0.03	0.03	
26	0.01	0.01	0.01	0.01	0.00	0.01	0.09	0.05	0.08	0.04	0.09	0.04	0.03	0.07	0.04	0.02	0.03	0.02	0.03	0.09	0.04	0.04	0.03	0.03	0.02	0.05	0.03	0.05	0.04	0.05	0.04	0.04	0.01	0.01	0.01	0.01	
27	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.05	0.01	0.01	0.04	0.03	0.04	0.01	0.02	0.03	0.02	0.03	0.01	0.01	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.04	0.04	0.01	0.01	0.01	0.01	0.02	
28	0.08	0.05	0.05	0.10	0.05	0.09	0.09	0.05	0.08	0.11	0.09	0.07	0.03	0.07	0.04	0.02	0.03	0.02	0.03	0.09	0.04	0.04	0.03	0.03	0.08	0.05	0.08	0.05	0.04	0.04	0.04	0.08	0.05	0.05	0.05	0.05	
29	0.05	0.03	0.03	0.01	0.03	0.09	0.09	0.03	0.05	0.04	0.03	0.04	0.03	0.04	0.04	0.02	0.03	0.02	0.03	0.03	0.01	0.04	0.03	0.03	0.05	0.02	0.03	0.05	0.01	0.05	0.04	0.04	0.05	0.03	0.03	0.03	
30	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.03	0.01	0.04	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.02	

(Continues)

TABLE 8 | (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Weight
31	0.02	0.05	0.05	0.01	0.05	0.09	0.03	0.05	0.08	0.04	0.09	0.07	0.03	0.07	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.05	0.05	0.08	0.04	0.08	0.04	0.04	0.02	0.05	0.04	
32	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.01	0.03	0.01	0.04	0.02	0.03	0.02	0.03	0.01	0.01	0.04	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.02	
33	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.04	0.03	0.04	0.03	0.04	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.09	0.03	0.02	0.05	0.03	0.05	0.04	0.05	0.04	0.04	0.05	0.03	0.04
34	0.08	0.05	0.05	0.10	0.05	0.03	0.03	0.05	0.08	0.04	0.03	0.04	0.03	0.07	0.04	0.02	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.02	0.02	0.05	0.04	0.05	0.04	0.04	0.08	0.05	0.04	
	$\sum_{\text{weight}} = 1$																																		

TABLE 9 | Ranking of particular criteria together with weights (own study).

Ranking	The name of the criterion	Weight
1.	Need for safety	6.30%
2.	Leadership styles	5.42%
3.	Values	4.40%
4.	Authority	4.25%
5.	Involvement of management	4.08%
6.	Working climate and risk perception	4.06%
7.	Self-realization	3.98%
8.	Sensing the involvement of management	3.87%
9.	Open and sincere communication	3.76%
10.	Strategy	3.69%
11.	Cooperation between employees	3.61%
12.	Satisfaction with safety	3.42%
13.	People's attitudes	3.41%
14.	Societal culture	3.40%
15.	Safety management system	3.40%
16.	Interpersonal relations	3.37%
17.	Employee participation	3.26%
18.	Social responsibility at work	2.99%
19.	Working conditions	2.98%
20.	Behavioral responses	2.89%
21.	Behavioral processes	2.79%
22.	Cognitive processes	2.47%
23.	Workload	2.34%
24.	Individual features, e.g., knowledge, skills, motivation	2.08%
25.	Structure	2.01%
26.	Hygiene and sanitary conditions	1.66%
27.	Employees' knowledge of safety	1.59%
28.	Physical environment, e.g., tools, machinery, organization of workstations	1.58%
29.	Socio-emotional support	1.49%
30.	Quality of safety management	1.30%
31.	Competence	1.22%
32.	Health and safety education	1.12%
33.	Norms (individual, interactional, organizational)	0.99%
34.	Results of accidents, incidents and potential accidents	0.82%

organizations determines our safety. In this form, the combination of components of safety culture with the determination of their impact forces and ranking determines the optimal model of this safety culture, the social impact of which has a crucial impact on human life and health. By synthesizing the results obtained in qualitative research by means of the Vester method, it can be concluded that core components that have the strongest impact on social impact due to the strong impact in both directions (i.e., factors that greatly affect social impact and at the same time social impact affects these individual factors to a lesser extent) are critical factors, which means that they have a strong impact on safety culture in which they function and are also significantly susceptible to it because their actions pose a threat of uncontrolled feedback. The most influential factors are: the need for safety (18.), behavioral processes (19.), cognitive processes (20.), behavioral reactions (21.), interpersonal relations (22.), satisfaction with safety (24.), strategy (26.), security management system (29.) and values (31.). The most active factor influencing safety culture and which at the same time has an average value of culture impact on this factor, which is a critical factor, is leadership styles (28). There were two active factors characterized by the highest impact on safety culture, namely health and safety education (4.) and socio-emotional support (14). Workload, which is a buffering factor, has a slight impact on safety culture and low flexibility in relation to this culture (11.). When assessing the place and role of passive factors in the research process, it is important to note that these factors have little influence on other system factors (low impact) and are highly dependent on other factors (high susceptibility to influence). They are characterized by low activity and do not initiate changes in the system. They are highly reactive, meaning they only react to what is happening. They lack controllability, so they cannot provide a platform for new changes. Although they do not control the system, they can nevertheless indicate its health. They also facilitate understanding the effects of actions within the system. Their in-depth analysis also allows for monitoring the effects of implemented changes. Passive factors have a low impact on safety culture, and they are also significantly influenced by safety culture. They include the results of accidents, incidents, and potential accidents (1.), quality of safety management (5) and hygiene and sanitary conditions (32).

As regards the use of the AHP method, which was used to determine a ranking of factors shaping the safety culture of a technical organization, the following results were obtained. The top five factors were classified, that is, the need for safety (18.), leadership styles (28.), values (31.), authority (2.) and the involvement of management (34.).

As regards the use of both methods, three factors were identified as the most important, namely the need for safety, leadership styles, and values. This means that stakeholders in a technical organization need a sense of safety using certain values shared with top management. It is important for the development of safety culture, as the social impact that the management is involved in safety management processes and in shaping safety culture using acceptable leadership styles.

9 | Conclusions

9.1 | Practical Implications

Safety is a social good and provides a platform for improving the quality of life of citizens. The modern social ecosystem is made up of technical products, the safety of which requires the implementation of appropriate management processes focused on technical, operational, and organizational aspects. Complex technical facilities managed by technical organizations have a strong impact on the sense of security and public acceptance of different stakeholder groups. Ensuring a positive safety culture for operational processes and work processes is a condition for processes conducted by technical organizations achieving a positive social impact. The component-structured safety culture, together with the determination of the relationship between them, creates a comprehensive model of social impact by technical organizations. The essence of safety culture emerges from this cognitive perspective as a foundation for the development of safety, the outcome of which is the life and health of people, both those working in such organizations and a wide range of other people who function in their ecosystem. Safety culture has a strong impact as a fundamental social impact of a technical organization. Without knowledge of factors that determine the development of a positive safety culture, these organizations cannot control the social impact they create.

9.2 | Summary of Key Findings

The concept of social impact presented in the article implemented by improving safety culture and operational processes (including work processes) requires knowledge of the relationship between factors of safety culture, including their hierarchy and importance.

Three fundamental final conclusions emerge from a number of observations:

1. Safety culture and its factor-based approach form the basis for determining how the social impact of technical organizations can be achieved.
2. Technical organizations should monitor the configuration of factors shaping safety culture to understand the social impact they create.
3. Safety culture in the context of the specificity of the functioning of a technical organization is an important aspect of understanding safety as a core attribute of achieving social good.

The final conclusions defined above demonstrate that a crucial mechanism for effective and efficient management of technical organizations is establishing an appropriate safety culture architecture based on social influence. This approach will enable safety criteria in technical organizations to be addressed coherently, combining aspects of safety engineering inherent to technical organizations with social elements through the appropriate configuration of safety culture attributes.

10 | Limitations and Suggestions for Future Research

A significant limitation in the field of the subject presented in the article is the limited amount of scientific research into the social impact of a technical organization based on the mechanisms of shaping safety culture. The methods used also represent a limitation to some extent as they result from their specific attributes and results relevant to the method. An important limitation, but also an advantage, is the fact that research was conducted for a specific type of organization, that is, a technical organization. A significant limitation affecting the results of the research is the selection of the research method, which is based on the existing models of safety culture presented in the current relevant literature. At the same time, the authors are aware that the article is a step towards defining processes for shaping a safety culture of technical organizations in the context of their social impact. The research can help technical organizations in the future to select such factors that build safety culture, which have a strong positive social impact.

It is worth adding that the results of research on the social impact on technical organizations can be used by regulatory bodies to create new standards in management and quality sciences and thus create broadly understood social value in technical organizations. As regards the need for further research related to the results presented, it is advisable to broaden knowledge and explore the subject of social impact investing by technical organizations. These issues are important not only in terms of theory, but also in utilitarian terms.

Acknowledgments

Open Access funding enabled and organized by Projekt DEAL.

References

- Bagnoli, L., and C. Megali. 2011. "Measuring Performance in Social Enterprises." *Nonprofit and Voluntary Sector Quarterly* 40, no. 1: 149–165. <https://doi.org/10.1177/0899764009351111>.
- Baker, D., R. Day, and E. Salas. 2006. "Teamwork as an Essential Component of High-Reliability Organizations." *Health Services Research* 41, no. 2: 1576–1598. <https://doi.org/10.1111/j.1475-6773.2006.00566.x>.
- Berends, J. J. 1995. *Developing and Using a Widely Applicable Measurement Tool for Safety Culture*. Eindhoven University of Technology.
- BITKOM Research. 2022. "Economic Protection 2022 [German]." <https://www.bitkom.org/Presse/Presseinformation/Wirtschaftsschuetz-2022>.
- Bourrier, M. 2011. "The Legacy of the High Reliability Organization Project." *Journal of Contingencies & Crisis Management* 19, no. 1: 9–13. <https://doi.org/10.1111/j.1468-5973.2010.00628.x>.
- BSI [German Federal Office for Information Security]. 2023. "The State of IT Security in Germany 2022 [German]." https://www.bsi.bund.de/SharedDocs/Downloads/DE/BSI/Publikationen/Lageberichte/Lagebericht2022.pdf?__blob=publicationFile&v=6.
- Busby, J., and M. Iszatt-White. 2014. "The Relational Aspect to High Reliability Organization." *Journal of Contingencies & Crisis Management* 22, no. 2: 69–80. <https://doi.org/10.1111/1468-5973.12045>.

- Casler, J. G. 2014. "Revisiting NASA as a High Reliability Organization." *Public Organization Review* 14, no. 2: 229–244. <https://doi.org/10.1007/s11115-012-0216-5>.
- Chanaron, J. J., and D. Jolly. 1999. "Technological Management: Expanding the Perspective of Management of Technology." *Management Decision* 37, no. 8: 613–621. <https://doi.org/10.1108/00251749910291578>.
- Choudhry, R. M., D. Fang, and S. Mohamed. 2007. "The Nature of Safety Culture: A Survey of the State-of-the-Art." *Safety Science* 45, no. 10: 993–1012. <https://doi.org/10.1016/j.ssci.2006.09.003>.
- Cooper, M. D. 2000. "Towards a Model of Safety Culture." *Safety Science* 36, no. 2: 111–136. [https://doi.org/10.1016/S0925-7535\(00\)00035-7](https://doi.org/10.1016/S0925-7535(00)00035-7).
- Cox, S., and A. J. T. Cheyne. 2000. "Assessing Safety Culture in Offshore Environments." *Safety Science* 34, no. 1: 111–129. [https://doi.org/10.1016/S0925-7535\(00\)00009-6](https://doi.org/10.1016/S0925-7535(00)00009-6).
- Cox, S., and T. Cox. 1991. "The Structure of Employee Attitudes to Safety: A European Example." *Work & Stress—An International Journal of Work, Health & Organisations* 5, no. 2: 93–106. <https://doi.org/10.1080/02678379108257007>.
- Cox, S., B. Jones, and D. Collinson. 2006. "Trust Relations in High-Reliability Organizations." *Risk Analysis* 26, no. 5: 1123–1138. <https://doi.org/10.1111/j.1539-6924.2006.00820.x>.
- Eagly, A. H., and S. Chaiken. 1993. *The Psychology of Attitudes*. Harcourt Brace Jovanovich.
- Ejdys, J., ed. 2010. *Kształtowanie kultury bezpieczeństwa i higieny pracy w organizacji*. Oficyna wydawnicza Politechniki Białostockiej.
- Emele Agwu, A., A. Labib, and S. Hadleigh-Dunn. 2019. "Disaster Prevention Through a Harmonized Framework for High Reliability Organisations." *Safety Science* 111: 298–312. <https://doi.org/10.1016/j.ssci.2018.09.005>.
- European Union Agency for Railways. 2018. "Guidance for Safety Certification and Supervision – Safety Management System Requirements for Safety Certification or Safety Authorization," Vallencienness.
- Filho, A. P. G., and P. Waterson. 2018. "Maturity Models and Safety Culture: A Critical Review." *Safety Science* 105: 192–211. <https://doi.org/10.1016/j.ssci.2018.02.017>.
- Fleming, M., and P. Joyner. 2002. "Towards a Mature Safety Culture." *Ins. Chem. E. No. 148*, Manchester.
- Geller, E. S. 1994. "Ten Principles for Achieving a Total Safety Culture." *Professional Safety* 9: 18–24.
- Glennon, D. P. 1982. "Measuring Organisational Safety Climate." *Australian Safety New*, 23–28.
- Grabowski, M., and K. H. Roberts. 2019. "Reliability Seeking Virtual Organizations: Challenges for High Reliability Organizations and Resilience Engineering." *Safety Science* 117: 512–522. <https://doi.org/10.1016/j.ssci.2016.02.016>.
- Graham, C. 2008. "The Role of an Education in the Behavioural Sciences Towards Contributing to a Safety Culture in the Maritime Industry." *Psychology*. <https://doi.org/10.13140/RG.2.1.1317.8322>.
- Guldenmund, F. W. 2010. *Understanding and Exploring Safety Culture*. Uitgeverij Boxpress.
- Hales, D. N., and S. S. Chakravorty. 2016. "Creating High Reliability Organizations Using Mindfulness." *Journal of Business Research* 69: 2873–2881. <https://doi.org/10.1016/j.jbusres.2015.12.056>.
- Health and Safety Executive (HSE). 1999. *Reducing Error and Influencing Behaviour HSG48*. HMSO.
- Hopkins, A. 2007. *WP 51—The Problem of Defining High Reliability Organisations*. National Research Centre for OHS Regulation.
- Hudson, P. 2001. "Safety Management and Safety Culture: The Long, Hard and Winding Road." In *Occupational Health & Safety Management*

- Systems: *Proceedings of the First National Conference*, edited by W. Pearce, C. Gallagher, and L. Bluff, 3–32. VIC: WorkCover NSW.
- Hudson, P. 2007. "Implementing a Safety Culture in a Major Multi-National." *Safety Science* 45, no. 6: 697–722. <https://doi.org/10.1016/j.ssci.2007.04.005>.
- Ishikawa, K. 1985. *What Is Total Quality Control?* Prentice Hall Inc.
- Islam, S. M. 2020. "Towards an Integrative Definition of Scaling Social Impact in Social Enterprises." *Journal of Business Venturing Insights* 13: e00164. <https://doi.org/10.1016/j.jbvi.2020.e00164>.
- IT-Security Cluster e.V. 2023. "The Next Step CISIS12-Information Security Management System." <https://cisis12.de/wp-content/uploads/2021/08/CISIS12-presentation.pdf>.
- Killian, S., and P. O'Regan. 2016. "Social Accounting and the Co-Creation of Corporate Legitimacy." *Accounting, Organizations and Society* 50: 1–12. <https://doi.org/10.1016/j.aos.2016.02.004>.
- Kopelman, R., A. Brief, and R. Guzzo. 1990. "The Role of Climate and Culture in Productivity." In *Organizational Climate and Culture*, edited by B. Schneider. Jossey Bass.
- La Porte, T. R. 1996. "High Reliability Organizations: Unlikely, Demanding and at Risk." *Journal of Contingencies & Crisis Management* 4, no. 2: 60–71. <https://doi.org/10.1111/j.1468-5973.1996.tb00078.x>.
- Le Coze, J. C. 2019a. "Vive la diversité! High Reliability Organisation (HRO) and Resilience Engineering (RE)." *Safety Science* 117: 469–478. <https://doi.org/10.1016/j.ssci.2016.04.006>.
- Le Coze, J. C. 2019b. "How Safety Culture Can Make Us Think." *Safety Science* 118: 221–229. <https://doi.org/10.1016/j.ssci.2019.05.026>.
- Lekka, C., and C. Sugden. 2011. "The Successes and Challenges of Implementing High Reliability Principles: A Case Study of a UK Oil Refinery." *Process Safety and Environmental Protection* 89, no. 6: 443–451. <https://doi.org/10.1016/J.PSEP.2011.07.003>.
- Lippert, S. K., and C. Govindarajulu. 2006. "Technological, Organizational, and Environmental Antecedents to Web Services Adoption." *Communications of the IIMA* 6, no. 1: 149.
- Maas, K., and K. Liket. 2011. "Social Impact Measurement: Classification of Methods." In *Environmental Management Accounting and Supply Chain Management*, edited by R. Burritt, S. Schaltegger, M. Bennett, T. Pohjola, and M. Csutora, 171–202. Springer. <https://doi.org/10.1007/978-94-007-1390-1>.
- Mitropoulos, P., and G. Cupido. 2009. "Safety as an Emergent Property: Investigation Into the Work Practices of High-Reliability Framing Crews." *Journal of Construction Engineering and Management* 135, no. 5: 407–415. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000002](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000002).
- Nævestad, T.-O., I. S. Hesjevoll, and R. O. Phillips. 2018. "How Can We Improve Safety Culture in Transport Organizations? A Review of Interventions, Effects and Influencing Factors." *Transportation Research Part F: Traffic Psychology and Behaviour* 54: 28–46. <https://doi.org/10.1016/j.trf.2018.01.002>.
- Olde Scholtenhuis, L. L., and A. G. Dorée. 2014. "High Reliability Organizing at the Boundary of the CM Domain." *Construction Management and Economics* 32, no. 7–8: 658–664. <https://doi.org/10.1080/01446193.2014.913801>.
- Pidgeon, N. F. 1991. "Safety Culture and Risk Management in Organisations." *Journal of Cross-Cultural Psychology* 22, no. 1: 129–140. <https://doi.org/10.1177/0022022191221009>.
- Pillay, M. 2014. "Progressing Zero Harm: A Review of Theory and Applications for Advancing Health and Safety Management in Construction." In *CIB W099 International Health and Safety Conference*. Lund, Sweden, 86–97.
- Piowarski, J. 2015. "Three Pillars of Security Culture." *Kultura Bezpieczeństwa. Nauka – Praktyka – Refleksje* 19: 34–44. <https://doi.org/10.24356/KB/19/2>.
- Reason, J. 1990. *Human Error*. Cambridge University Press.
- Reason, J. 2000. "Human error: models and management." *BMJ* 320, no. 7237: 768–770. <https://doi.org/10.1136/bmj.320.7237.768>.
- Roberts, K. H. 1989. "New Challenges in Organizational Research: High Reliability Organizations." *Industrial Crisis Quarterly* 3, no. 2: 111–125. <https://doi.org/10.1177/108602668900300202>.
- Roberts, K. H. 1990. "Some Characteristics of High-Reliability Organizations." *Organization Science* 1, no. 2: 160–177. www.jstor.org/stable/2635060.
- Rogers, E. M. 2010. *Diffusion of Innovations*. 4th ed. Free Press.
- Saaty, R. W. 1987. "The Analytic Hierarchy Process-What It Is and How It Is Used." *Mathematical Modelling* 9, no. 3–5: 161–176. [https://doi.org/10.1016/0270-0255\(87\)90473-8](https://doi.org/10.1016/0270-0255(87)90473-8).
- Sairinen, R., O. Sidorenko, and H. Tiainen. 2021. "A Research Framework for Studying Social Impacts: Application to the Field of Mining." *Environmental Impact Assessment* 86: 106490. <https://doi.org/10.1016/j.eiar.2020.106490>.
- Samuels, J. G. 2010. "The Application of High-Reliability Theory to Promote Pain Management." *JONA, Journal of Nursing Administration* 40, no. 11: 471–476. <https://doi.org/10.1097/NNA.0b013e3181f88a41>.
- Saunders, F. C. 2015. "Toward High Reliability Project Organizing in Safety-Critical Projects." *Project Management Journal* 46, no. 3: 25–35. <https://doi.org/10.1002/pmj.21498>.
- Sein, M. K. 2011. "Action Design Research." *MIS Quarterly* 35, no. 1: 37–56.
- Sharon, G. C. 2000. "Safety Culture: Under-Specified and Overrated?" *International Journal of Management Reviews* 2, no. 1: 65–90. <https://doi.org/10.1111/1468-2370.00031>.
- Slootweg, R., F. Vanclay, and M. van Schooten. 2001. "Function Evaluation as a Framework for the Integration of Social and Environmental Impact Assessment." *Impact Assessment and Project Appraisal* 19, no. 1: 19–28. <https://doi.org/10.3152/147154601781767186>.
- Studenski, R. 2000. "Kultura bezpieczeństwa pracy w przedsiębiorstwie." *Bezpieczeństwo Pracy* 9: 1–4.
- Sutcliffe, K. M. 2011. "High Reliability Organizations (HROs)." *Best Practice & Research. Clinical Anaesthesiology* 25: 133–144. <https://doi.org/10.1016/j.bpa.2011.03.001>.
- Tello, M. A. 2020. "Conceptualizing Social Impact: A Geographic Perspective." *Journal of Business Research* 119: 562–571. <https://doi.org/10.1016/j.jbusres.2020.07.040>.
- Tornatzky, L. G., and M. Fleischer. 1990. *The Processes of Technological Innovation*. Lexington Books.
- Vanclay, F., A. M. Esteves, E. Aucamp, and D. M. Franks. 2015. "Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Project." In *IAIA*. www.iaia.org/uploads/pdf/SIA_Guidance_Document_IAIA.pdf.
- Vester, F. 1975. *Denken, Lernen, Vergessen [Thinking, Learning, Forgetting]*. Deutsche Verlags-Anstalt. Pocketbook Edition, 1978 (27th Edition, 2001). Munich: dtv.
- Vester, F. 1976. *Ballungsgebiete in der Krise [Urban Areas in Crisis]*. Deutsche Verlags-Anstalt. Pocketbook Edition, 1983 (5th Edition, 1994). Munich: dtv.
- Vester, F. 1978. *Unsere Welt - ein vernetztes System [Our World—A Networked System]*. Klett-Cotta. Pocketbook Edition, 1983 (10th Edition, 1999). Munich: dtv.
- Vester, F. 1984. *Ökopololy, ein kybernetisches Umweltspiel von Frederic Vester [An Environmental Cardboard Game]*. Otto Maier Verlag.
- Vester, F. 1988. "The Bio-Cybernetic Approach as a Basis for Planning Our Environment." *Systems Practice* 1, no. 4: 399–413 (Special Issue: C. West Churchman - 75 Years, Editor: W. Ulrich).

Vester, F. 1989. *Ökolopoly PC-Version, Das kybernetische Umweltspiel von Frederic Vester [An Environmental Computer Game]*. Studiengruppe für Biologie und Umwelt GmbH.

Wang, C.-H., and Y.-J. Liu. 2012. "Omnidirectional Safety Culture Analysis and Discussion for Railway Industry." *Safety Science* 50: 1196–1204. <https://doi.org/10.1016/j.ssci.2011.12.031>.

Weber, K., and A. Schütz. 2018. "ISIS12-Hack: Sensitizing Employees Instead of Informing Them." *Multiconference Business Informatics* 4: 1737–1748.

Weick, K. E., and K. M. Sutcliffe. 2001. *Managing the Unexpected: Assuring High Performance in an Age of Complexity*. Jossey-Bass.

Weick, K. E. S., M. Kathleen, and D. Obstfeld. 2008. "Organizing for High Reliability: Processes of Collective Mindfulness." *Crisis Management* 3: 81–123.

Youngberg, B. J. 2004. "Assessing Your Organization's Potential to Become a High Reliability Organization." *Journal of Healthcare Risk Management* 24, no. 3: 13–20. <https://doi.org/10.1002/jhrm.5600240304>.

Zohar, D. 1980. "Safety Climate in Industrial Organizations: Theoretical and Applied Implications." *Journal of Applied Psychology* 65, no. 1: 96–102. <https://doi.org/10.1037/0021-9010.65.1.96>.

Żurakowski, Z. 2015. "Kultura bezpieczeństwa w przedsiębiorstwie." *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie* 77: 323–330.