



Izzivi prihodnosti

Challenges of the Future

Letnik 11, številka 3, avgust 2026

Volume 11, Issue 3, August 2026



UNIVERZA V NOVEM MESTU
UNIVERSITY OF NOVO MESTO
Fakulteta za organizacijske študije
Faculty of Organizational Studies

ISSN 2232-5204

ISSN 2463-9281

Izid publikacije Izzivi prihodnosti je finančno podprla ARIS iz naslova razpisa za sofinanciranje domačih znanstvenih periodičnih publikacij.
The journal Challenges of the Future is subsidised by the Slovenian Research and Innovation Agency.

GLAVNA IN ODGOVORNA UREDNICA / ANNMARIE GORENC ZORAN
EDITOR IN CHIEF

SOUREDNIČE / TATJANA DRAGOVIČ ANDERSEN
ASSOCIATE EDITORS
LANA HIASAT
NADIA MOLEK

UREDNIŠKI ODBOR /
EDITORIAL BOARD

- Boris Bukovec, Faculty of Organisation Studies in Novo mesto, Slovenia
- Alois Paulin, Technical University Vienna, Austria
- Juraj Marušiač, Slovak Academy of Science, Slovakia
- Mario Ianniello, Udine University, Italy
- Anisoara Popa, Danubius University, Romania
- Raluca Viman-Miller, University of North Georgia, Georgia, USA
- Anna Kołomycew, Rzeszów University, Poland
- Jurgita Mikolaityte, Siauliai University, Lithuania
- Patricia Kaplanova, Faculty of Organisation Studies in Novo mesto, Slovenia
- Laura Davidel, University of Lorraine, France
- Ana Železnik, Ljubljana University, Slovenia
- Marko Vulić, Information Technology School - ITS ComTrade, Serbia
- Vita Juknevičienė, Siauliai University, Lithuania
- Mitja Durnik, Ljubljana University, Slovenia
- Anca-Olga Andronic, Spiru Haret University, Romania
- Razvan-Lucian Andronic, Spiru Haret University, Romania
- Tine Bertonec, Faculty of Organisation Studies in Novo mesto, Slovenia
- Nadia Molek, Faculty of Organisation Studies in Novo mesto, Slovenia
- Maja Meško, University of Maribor, Faculty of Organizational Sciences, Slovenia
- Agnieszka Wedel-Domaradzka, Faculty of Law and Economics, Kazimierz Wielki University, Bydgoszcz, Poland
- Armand Faganel, University of Primorska, Faculty of Management, Slovenia
- Elżbieta Roszko-Wójtowicz, University of Lodz, Poland
- Gorazd Justinek, New University, Faculty of Government and European Studies
- Danyana Bakardzhieva, Anwar Gargash Diplomatic Academy, United Arab Emirates (UAE)
- Bashar H. Malkawi, University of Arizona James E. Rogers College of Law, USA
- Kodzo Alabo, University of Ghana, Salt University College, Ghana
- Robert Mudida, Strathmore University Business School, Nairobi, Kenya
- Juan Carlos Radovich, Universidad de Buenos Aires, Argentina
- Anurag Hazarika, Tezpur Central University, Assam, India & 21st century Open University, USA

Naslov uredništva / Editorial address:

Univerza v Novem mestu, Fakulteta za organizacijske študije

Ulica talcev 3

8000 Novo mesto, Slovenija



Licenca CC BY-SA 4.0 omogoča prosto uporabo, prilagajanje in distribucijo dela, tudi v komercialne namene, pod pogojem, da se prizna avtorstvo in ohrani enaka licenca pri deljenih predelavah. To zagotavlja odprtost in širjenje vsebine pod enakimi pogoji.

KAZALO VSEBINE

TABLE OF CONTENTS

62

**VIABLE SYSTEMIC MODEL AND DIGITAL
DELIBERATIVE DEMOCRACY: A CYBER
FRAMEWORK FOR RESILIENCE, INCLUSION
AND ADAPTABILITY**

Vasja Roblek

101

**DELOVNE OBREMENITVE V DOBI UMETNE
INTELIGENCE: RAZISKOVALNI TRENDI**

Tilen Medved, Zvone Balantič

Viable Systemic Model and Digital Deliberative Democracy: a Cyber Framework for Resilience, Inclusion and Adaptability

Vasja Roblek¹  

¹Independent Researcher, Ljubljana, Slovenia 

Abstract

Research Question (RQ): To what extent, and in what ways, can the Viable System Model (VSM), strengthened by Donella Meadows' leverage-point perspective, provide actionable and systemic guidance for transforming digital democratic systems to enhance their resilience, adaptability, and inclusiveness?

Purpose: The purpose of the study is to develop an analytical and transformative framework for diagnosing structural weaknesses in digital platforms, while simultaneously identifying leverage points for intervention. The framework is intended to support a shift from digital participation, understood as a technical instrument, to digital deliberation, conceived as a viable, recursive, and learning democratic system.

Method: The study adopts a theoretical approach that combines a qualitative review of the relevant literature with a structured analysis of seven platform cases. The Viable System Model serves as a coding matrix for mapping platforms across five subsystems, while Meadows' leverage points are employed as a heuristic tool for identifying transformative interventions. Qualitative coding and synthesis were conducted using NVivo.

Results: The analysis shows that most platforms exhibit asymmetric subsystem development. Coordination (System 2) frequently emerges as the main bottleneck, strategic intelligence (System 4) is insufficiently integrated, and normative identity (System 5) often remains at a merely declarative level. Feedback loops are predominantly one-directional, and recursive structures are rare. Among the platforms, vTaiwan stands out as a good practice example, having consistently implemented all VSM functions and developed bidirectional feedback loops.

Organisation: The findings are relevant for platform developers, municipal administrations, and public institutions seeking to design more resilient and legitimate digital participatory systems. The study proposes, among other measures, standardised moderation protocols, binding mechanisms for institutional response, and the integration of strategic analytical tools into governance and management processes.

Society: The study contributes to understanding how digital deliberative platforms can strengthen democratic legitimacy, particularly through the inclusion of marginalised groups and the reinforcement of trust in institutions. It also addresses risks associated with algorithmic bias, disinformation, and unequal access to information, underlining the need for appropriate regulatory frameworks at both the EU and national levels.

Originality: The paper's originality lies in the systematic integration of VSM and Meadows' leverage points into a two-step framework for analysing digital deliberative systems. While VSM has previously been applied to organisational systems, its combination with Meadows' theory of leverage points in the specific context of digital democracy offers a novel analytical paradigm.

Limitations / further research: The primary limitation of the study is its theoretical nature, as it does not empirically test the proposed framework within specific institutional settings. The dynamic character of digital platforms and the fast pace of technological change also limit the generalisability of the findings. Future research should empirically validate the framework in real-world digital deliberative processes, develop longitudinal studies of platforms, and conduct comparative analyses across diverse cultural and institutional contexts.

Keywords: digital deliberative democracy, viable systemic model, leverage points, cybernetics, governance, feedback loops, online participatory platforms, digital democratic innovation.

1 Introduction

The digital transformation of European public administration and democracy has intensified long-standing concerns about legitimacy, responsiveness, and inequality in participatory governance (European Commission, JRC, 2025; OECD, 2022). Online participation tools broaden opportunities for citizen involvement in policymaking, yet they also expose democratic systems to new risks, including disinformation, polarisation, and uneven deliberative quality (Le Blanc, 2020; Mikhaylovskaya, 2024; European Union, 2024). At the same time, the expansion of digital public services raises questions about surveillance, privacy, and information security, underscoring the need for regulatory frameworks that protect fundamental rights while enabling innovation (European Data Protection Supervisor, 2022; European Union, 2016, 2022).

Despite high expectations, many digital deliberative platforms struggle to translate participation into effective institutional change. Fragmented coordination, weak feedback loops between deliberation and implementation, and limited integration of learning mechanisms frequently undermine their democratic potential (European Commission, Joint Research Centre [JRC], 2025; Le Blanc, 2020). In this article, digital deliberation is therefore not treated as a sequence of isolated participation events, but as a complex socio-technical system whose performance depends on how information flows, coordination mechanisms, control structures, strategic intelligence, and normative commitments are organised and interconnected (Beer, 1985; Meadows, 2008; van Der Heijden, 2022).

The article is primarily a conceptual and theoretical contribution. It develops an analytical framework that combines Stafford Beer's Viable System Model (VSM) with Donella Meadows' theory of leverage points to diagnose and transform digital deliberative systems. Rather than presenting a comprehensive empirical evaluation of specific platforms, the study proposes a structured conceptual model that is illustrated through a comparative analysis of selected cases.

The empirical material – including the historical Cybersyn project and contemporary platforms such as vTaiwan, Decidim, Loomio, EUComMeet, MultiPoD, and Consul Democracy – is used to demonstrate the applicability and limits of the framework in diverse institutional and technological contexts, not to derive statistically generalisable findings (Beer, 1985; Espejo, 2022; Decidim, 2026; EUComMeet, 2024; Loomio, n.d.; MultiPoD, 2025).

For the purposes of this study, viability is defined as the capacity of a digital deliberative system to maintain functional coherence, democratic legitimacy, and adaptive responsiveness over time under conditions of social, technological, and institutional complexity. Analytically, this concept refers to five interrelated dimensions: (1) operational performance, (2) coordination, (3) institutional control and responsiveness, (4) strategic intelligence and learning, and (5) normative identity. Viability thus serves as an overarching systemic notion that integrates and organises related properties such as legitimacy, resilience, adaptability, and inclusiveness, without reducing it to any single one of these dimensions (Beer, 1985; Meadows, 2008). This operational definition responds to the risk of conceptual vagueness associated with broad, unspecific uses of the term and provides a basis for systematic comparison across platforms.

Building on systems thinking and cybernetics, the article employs the VSM as an organisational diagnostic tool. VSM conceptualises viable organisations as composed of interdependent subsystems – operations, coordination, control, intelligence, and identity – linked by recursive feedback loops across multiple levels (Beer, 1985). In the context of digital deliberation, these subsystems can be mapped onto platform architectures, governance models, and deliberative processes, enabling a structured analysis of how platforms balance autonomy and cohesion, and how they manage complexity (Beer, 1985; Meadows, 2008).

Meadows' leverage points provide a complementary theory of systemic change by identifying strategic locations, such as information flows, rules, goals, and paradigms, where relatively small interventions can generate disproportionate effects (Meadows, 2008; OECD, 2022). Methodologically, the article combines a systematic review of literature with a structured document-based case analysis. This diagnosis is then linked to Meadows' framework to identify impactful interventions for enhancing resilience, adaptability, and inclusiveness. The approach is exploratory and interpretive, seeking to provide a theoretically grounded lens for future empirical research rather than to exhaustively measure platform performance (Braun & Clarke, 2006; Yin, 2018). Guided by this perspective, the research question is: *How and to what extent can the Viable System Model, strengthened by Meadows' leverage-point perspective, offer actionable, systematic guidance for transforming digital democratic systems in ways that enhance their resilience, adaptability, and inclusiveness?*

To address this question, Section 2 develops the theoretical framework, integrating deliberative democracy, cybernetics, VSM, and leverage points, and situates contemporary digital platforms and AI-supported infrastructures within this perspective. Section 3 outlines the methodological

design, including case selection, coding procedures, and analytical strategy. Section 4 presents the results of the VSM-based comparative analysis of digital deliberative platforms, highlighting recurring patterns and systemic gaps. Section 5 discusses how Meadows' leverage points can be combined with VSM to move from diagnosis to transformation and reflects critically on the limitations of the framework. Section 6 concludes with implications for research and practice in the design of viable digital deliberative systems.

2 Theoretical framework

Digital democratic innovation increasingly relies on participation and deliberation mediated by electronic platforms, prompting closer examination of how complex socio-technical systems sustain legitimacy, inclusiveness, and adaptability under conditions of rapid technological and political change (European Commission, JCR, 2025; Le Blanc, 2020). Contemporary democratic governance is shaped not only by formal institutions and electoral mechanisms but also by digitally mediated communicative environments that structure how information circulates, how preferences are articulated, and how collective problems are framed and addressed (Nesta, 2022; OECD, 2024). In this context, online deliberative platforms are best understood not as neutral tools but as organisational and normative arrangements that influence the quality, reach, and effects of democratic participation.

Systems thinking and cybernetics offer a productive conceptual lens for analysing these developments. Rather than treating governance as a stable institutional structure, they conceptualise it as an adaptive process shaped by feedback loops, information flows, learning, and recursive coordination across multiple levels (Beer, 1985; Meadows, 2008). This perspective is particularly useful for understanding digital deliberation, where institutional design, moderation rules, authentication systems, algorithmic curation, and feedback mechanisms jointly shape whose voices are heard, how conflicts are processed, and whether deliberation leads to meaningful institutional response (European Commission, JRC, 2025; van der Heijden, 2022).

This article adopts a primarily conceptual and theoretical perspective. Its aim is not to provide an exhaustive empirical evaluation of digital democracy platforms, but to develop and refine an analytical framework for examining their organisational viability and transformative potential. The empirical cases discussed later in the article serve as structured illustrations of the framework in use rather than as a basis for statistical generalisation. The contribution of the article lies above all in conceptual integration: it brings Stafford Beer's VSM into dialogue with deliberative democracy theory and Donella Meadows' leverage-point framework to explain how digital deliberative systems can be diagnosed and, potentially, redesigned.

Deliberative democracy is conventionally associated with the principle that legitimate collective decisions must be grounded in public reasoning under conditions that ensure inclusion,

reciprocity, and mutual justification of positions (Gutmann & Thompson, 1996; Habermas, 1996). Digital deliberation extends these principles into virtual environments, where citizens and organised stakeholders engage in structured online communication oriented toward mutual understanding, preference transformation, and collective problem solving. Its normative promise lies not only in widening access to participation, but also in improving transparency, traceability, and responsiveness in public decision-making (Le Blanc, 2020; OECD, 2022).

Digital deliberative environments are marked by substantial tensions. They may reproduce or intensify inequalities in voice, visibility, and access; they may be vulnerable to manipulation, disinformation, and low-quality discourse; and they often struggle to connect participatory input to concrete policy outcomes (Kennedy et al., 2020). These tensions indicate that the democratic value of digital participation depends not simply on the existence of participatory tools, but on the organisational architecture through which participation is coordinated, interpreted, and translated into action (European Commission, JRC, 2025; Jiménez-Pernett et al., 2023).

From a cybernetic perspective, democracy can be conceptualised as a dynamic governance process in which goals, norms, and problem definitions evolve over time and must be continuously adjusted in response to new information and changing conditions (Beer, 1985; Meadows, 2008). Democratic systems, on this view, require mechanisms for perceiving environmental change, processing distributed signals, coordinating multiple actors, and revising institutional responses when existing arrangements prove inadequate. Digital deliberation is therefore not merely a communicative supplement to representative democracy, but a potentially important site of systemic learning and adaptation.

2.1 Viability as an analytical concept

A central concept in this article is viability. In this study, viability is defined as the capacity of a digital deliberative system to maintain functional coherence, democratic legitimacy, and adaptive responsiveness over time under conditions of social, technological, and institutional complexity. Viability refers neither to mere organisational survival nor to technical efficiency alone. Rather, it concerns the extent to which a deliberative system can continue to operate, learn, and retain democratic credibility while facing changing demands, internal tensions, and external disturbances (Beer, 1985; Meadows, 2008).

Viability is treated here as an overarching systemic property composed of five interrelated analytical dimensions: operational performance, coordination, institutional control and responsiveness, strategic intelligence and learning, and normative identity (Beer, 1985; Meadows, 2008). Operational performance concerns whether the platform enables actual deliberative activity (Beer, 1985). Coordination concerns whether interactions, conflicts, and procedural flows are managed in a coherent manner (Beer, 1985). Control and responsiveness refer to governance capacity, rule enforcement, and the ability of institutions to respond to

outputs (Beer, 1985; Espejo & Reyes, 2011). Strategic intelligence captures monitoring, analysis, experimentation, and adaptation (Beer, 1985; Meadows, 2008). Normative identity concerns the values, principles, and democratic commitments that orient the system as a whole (Beer, 1985; Gutmann & Thompson, 1996).

This definition also distinguishes viability from adjacent concepts that appear throughout the literature, such as resilience, inclusiveness, legitimacy, and sustainability (Beer, 1985; Meadows, 2008). These concepts are not treated as synonyms. Rather, they are understood as important dimensions or consequences of viability, depending on the analytical context (Beer, 1985; Gutmann & Thompson, 1996; OECD, 2022). Such clarification is necessary in order to avoid conceptual overstretch and to provide a more precise basis for the comparison of digital platforms (Espejo & Reyes, 2011; Meadows, 2008).

2.2 Deliberative democracy and cybernetic governance

The theoretical contribution of this article emerges from the intersection of deliberative democratic theory and cybernetic systems thinking. Deliberative theory emphasises that legitimacy depends on the quality of public reasoning, the inclusion of diverse perspectives, and the existence of procedures that allow arguments to be exchanged, challenged, and revised (Gutmann & Thompson, 1996; Habermas, 1996). Cybernetics, by contrast, focuses on how complex systems regulate themselves through communication, control, and adaptation. Combining these perspectives makes it possible to ask not only whether participation occurs, but also how deliberative systems are organised, how they process complexity, and how they convert communicative input into institutional learning.

This combination is important because digital deliberative systems are not purely normative spaces, nor merely technical infrastructures (Baxter & Sommerville, 2011; Beer, 1985). They are socio-technical and political formations in which platform design, rules, actors, and institutional settings jointly affect deliberative outcomes (Baxter & Sommerville, 2011; European Commission, JRC, 2025). A cybernetic perspective makes visible the organisational conditions that support or undermine deliberative quality, including broken feedback loops, weak coordination, excessive centralisation, poor intelligence functions, and unstable normative orientation (Beer, 1985; Espejo & Reyes, 2011). In this sense, cybernetics does not replace deliberative democratic theory; it complements it by adding a systems-oriented account of how democratic communication is sustained, coordinated, and adapted over time (Gutmann & Thompson, 1996; Habermas, 1996; Beer, 1985).

2.3 Cybernetic architecture of digital deliberation: from Cybersyn to contemporary platforms

Studies show that the intertwined crisis of trust in representative democracy and the increasing complexity of public problems, ranging from urban infrastructure to youth precarity, reinforce the

need for governance systems that can learn and adapt continuously rather than relying solely on multi-year electoral cycles (Nabatchi & Leighninger, 2023; Wagenaar, 2022). In such environments, the responsiveness of democratic institutions depends on their ability to perceive changes in real time, integrate dispersed information, and adjust decisions accordingly (Beer, 1985; Fung, 2015).

Historically, one of the most ambitious attempts to operationalise such a cybernetic architecture was the Cybersyn project in Chile (1971–1973), designed by Stafford Beer as an application of organisational cybernetics to national economic management (Medina, 2011). Cybersyn combined a nationwide telex network, statistical control software, simulation tools, and a central operations room into an integrated system that structured information flows across geographically dispersed production units (Beer, 1979; Medina, 2011). Although often portrayed as a technocratic command centre, the project was conceived as a decentralised system in which local operational autonomy was preserved and central coordination functioned primarily as a supportive mechanism for managing complexity and responding to disturbances (Beer, 1979; Espejo & Reyes, 2011).

The epistemological basis of early cybernetics was often rooted in a “black box” model that prioritised the observation of input-output relations and the regulation of system behaviour through external control of information (Beer, 1981). Later developments in second-order cybernetics substantially shifted this perspective by insisting that observers are themselves part of the systems they analyse and influence. In this view, cognition is relational, autonomy is central, and adaptation depends on the system’s internal capacity to respond to environmental disturbances through structural change rather than direct command (Maturana & Varela, 1987; Pickering, 2010). This shift is highly relevant for deliberative democracy because it foregrounds participation, reflexivity, and self-organisation as constitutive features of viable governance.

2.4 The Viable System Model as a framework for digital deliberation

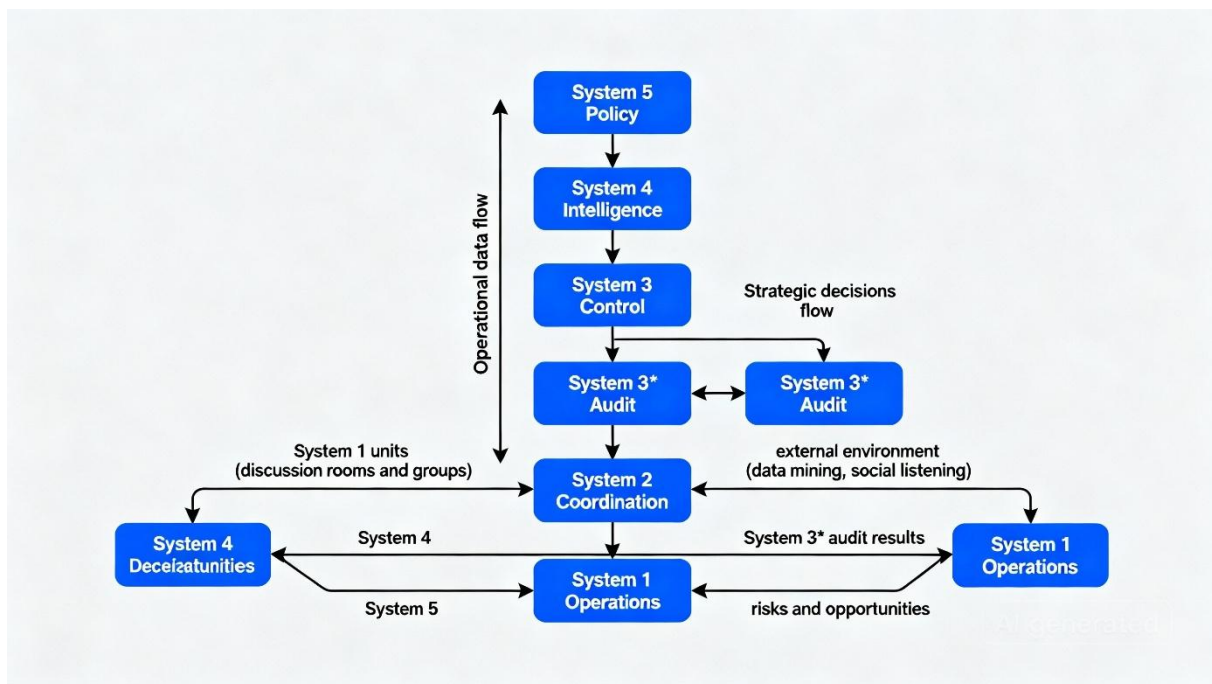
The Viable System Model (VSM), developed by Stafford Beer, conceptualises any viable organisation as composed of five interdependent functional subsystems: System 1 (operations), System 2 (coordination), System 3 (control and internal regulation), System 4 (intelligence, learning, and strategy), and System 5 (policy, identity, and normative orientation) (Beer, 1981, 1985). A defining feature of the VSM is recursion, meaning that the same functional architecture must be reproduced across organisational levels if local autonomy is to coexist with systemic coherence. This principle is closely connected to Ashby’s law of requisite variety, according to which only a system with sufficient internal variety can absorb environmental complexity without becoming unstable or unresponsive (Ashby, 1958). From this perspective, viability does not simply mean survival, but the capacity of a system to maintain coherent functioning, adapt to changing environments, and preserve its identity over time.

For the purposes of this study, the classical VSM is adapted to the analysis of digital deliberative platforms. In this interpretation, System 1 refers to concrete deliberative activities and operational participation units, such as online discussions, proposal submission processes, or mini publics. System 2 refers to process coordination, including moderation, facilitation, conflict management, interoperability protocols, and other mechanisms that stabilise interactions between operational units. System 3 refers to governance structures, institutional oversight, rule enforcement, compliance procedures, and resource allocation, through which platform activity is regulated and connected to authoritative decision making. System 3 is interpreted as an audit function, understood as independent monitoring, verification, evaluation, and quality assessment of deliberative processes. System 4 refers to strategic intelligence, including analysis, experimentation, environmental scanning, use of analytics and AI supported synthesis, and institutional learning. System 5 refers to broader normative and constitutional commitments that define the platform's identity and long-term orientation, such as democratic charters, constitutional principles, ethical frameworks, and visions of participation (Beer, 1985; Espejo & Reyes, 2011)

Figure 1 presents the adapted VSM framework used in this study. It visualises the vertical information flows between subsystems, the horizontal links between operational deliberative units and the external environment, and the feedback loops through which the system monitors, coordinates, and adjusts its own functioning. By making the audit function explicit, the model highlights the importance of independent reflexive capacity in digital deliberative environments, where transparency, accountability, and democratic quality cannot be assumed but must be continuously assessed (Beer, 1985; Espejo & Reyes, 2011). In this way, the model provides an organisational lens that connects micro level participatory practices with meso level coordination and macro level strategic and normative orientations.

Figure 1

Beer's capable system model expanded for digital deliberation



This framework is particularly relevant for contemporary digital platforms, which can be interpreted as updated forms of cybernetic governance organised through digital infrastructures, information flows, and institutional feedback mechanisms (Espejo, 2022; Fischli & Muldoon, 2024; Mikhaylovskaya, 2024). Taiwan's vTaiwan process, for example, combines online tools such as Pol.is with face-to-face meetings and institutional follow up, using algorithmic mapping of opinion landscapes to identify bridging statements and support structured consensus formation connected to policy processes (Cheng & Godel, 2021). Decidim integrates open-source infrastructure, procedural traceability, and a democratic charter, thereby linking operational participation modules with coordination mechanisms and explicit normative commitments within a comparatively coherent participatory architecture. These examples suggest that digital deliberative systems can be designed as recursive, learning oriented institutional ecosystems rather than as isolated participatory events, and that their democratic performance depends on how well the different VSM functions are articulated and balanced.

In the remainder of the article, the adapted VSM is used as a diagnostic framework for analysing the organisational architecture of selected digital deliberative platforms. The five subsystems and the audit function are not only treated as theoretical categories but are also translated into an explicit coding matrix that structures the qualitative document analysis. This alignment between conceptual model and analytical categories enables comparison at the level of functional architecture rather than only visible technological features and provides a transparent basis for the subsequent coding procedure and cross case synthesis (Beer, 1985; Espejo & Reyes, 2011).

2.5 Meadows' leverage points and systemic transformation

While the VSM offers a diagnostic framework for identifying functional strengths and weaknesses, it says less about where and how change should be initiated once systemic problems have been identified. This is where Meadows' theory of leverage points becomes analytically valuable. Meadows (2008) distinguishes between different locations within a complex system where interventions can produce effects, ranging from parameters and buffers to information flows, rules, system goals, and paradigms. These leverage points differ in depth: interventions at the level of parameters may be easier to implement but tend to generate limited change, whereas interventions at the level of goals or paradigms are more difficult but potentially transformative.

In the context of digital deliberative democracy, leverage points help translate systemic diagnosis into institutional and design-oriented reflection. Information flows concern whether participants receive timely, understandable, and traceable feedback. Rules concern moderation, access, participation procedures, and obligations of institutional response. Goals concern whether platforms are oriented merely toward consultation or toward continuous co-governance and learning. Paradigms concern the deeper assumptions institutions hold about democracy itself, including whether citizens are seen as passive consultees or as co-producers of public problem solving (Meadows, 2008; OECD, 2022). The combination of VSM and leverage points therefore establishes a two-step analytical logic that is central to this article. First, VSM is used to diagnose the functional architecture of the system and identify where viability is compromised. Second, Meadows' leverage points are used to specify where interventions may be most effective and how deep those interventions would need to be to improve resilience, inclusiveness, responsiveness, and learning. This integrated formulation makes the conceptual contribution of the article more explicit and clarifies the relationship between diagnosis and transformation.

2.6 Artificial intelligence and digital twins in deliberative systems

Recent developments in artificial intelligence (AI) and data-intensive infrastructures are further transforming the conditions under which digital deliberation takes place. AI-supported platforms can process large volumes of citizen input, identify argumentative patterns, cluster positions, and generate summaries at a scale that would be difficult to manage through human facilitation alone (Fishkin et al., 2025; Romberg & Escher, 2024). In this sense, AI can extend the intelligence function of deliberative systems by supporting analysis, pattern recognition, and the management of informational complexity (Fishkin et al., 2025; Tessler et al., 2024).

At the same time, AI raises substantial normative and regulatory questions. Systems used in public decision-making must remain transparent, subject to human oversight, and designed so as not to manipulate participants or conceal the criteria through which inputs are processed

(European Commission, 2026). Within the European context, the AI Act introduces a risk-based framework that is directly relevant for deliberative systems supported by algorithmic tools (European Commission, 2026). From the perspective of the VSM, AI may strengthen System 4 through analytical capacity and System 3 through monitoring and audit, but only if embedded within clear governance arrangements and normative safeguards (Beer, 1985; Espejo & Reyes, 2011).

Digital twins represent a related development. By simulating policy scenarios and visualising possible consequences in real time, they create new possibilities for connecting deliberation with anticipatory governance (Eurocities, 2024; OECD, 2025). However, as recent developments in Argentina demonstrate, extending this logic to social policy raises profound democratic concerns. The implementation of a national “Social Digital Twin” by the Argentine government in 2026, designed to simulate the socioeconomic impacts of welfare policies by centralising citizen data, illustrates how predictive state modelling can blur the line between policy anticipation and mass surveillance (DigWatch, 2026; NextMSC, 2026). From a cybernetic perspective, such systems may strengthen intelligence functions (System 4), but without robust normative safeguards (System 5) and democratic control (System 3*), they risk reducing citizens from deliberative actors to passive, algorithmically profiled variables. In urban policy, environmental planning, and mobility governance, digital twins can make complex trade-offs visible to citizens and decision-makers alike, thereby supporting more informed forms of participation (Eurocities, 2024; Living-in.EU, 2024). They also enrich feedback processes by allowing deliberation to engage not only with past performance but with modelled future consequences, for example through local digital twins that simulate policy scenarios and visualise potential impacts (Raes et al., 2025).

2.7 Critical application of the framework

Despite its analytical power, the VSM cannot be applied uncritically to democratic processes. Its structural elegance may obscure questions of power, inequality, legitimacy, and contestation if it is treated as a purely technical model of optimisation (Beer, 1985; Jiménez-Pernett et al., 2023). Digital deliberation is shaped not only by functional design but also by asymmetries in access, discourse quality, institutional trust, and the broader political context in which participatory mechanisms operate. These issues are especially significant in online environments, where inequalities can arise at the stages of recruitment, interaction, visibility, and uptake of outcomes.

For this reason, the VSM is employed in this article not as a technocratic blueprint for governing democracy, but as a conceptual framework that must remain anchored in normative deliberative theory and sensitive to institutional power. This critical qualification is important because the article does not claim that cybernetic design by itself guarantees democratic legitimacy. Rather, it argues that cybernetic and systems-theoretical concepts can help diagnose organisational

conditions under which deliberative democracy is more or less likely to become viable in practice.

3 Method

This study is primarily designed as a conceptual-theoretical inquiry supported by a structured comparative analysis of selected digital deliberative platforms. Its purpose is not to produce statistically generalisable findings, but to develop and apply an analytical framework capable of diagnosing the organisational and normative conditions of viability in digital deliberative systems. Methodologically, the study combines document analysis, systems modelling through the Viable System Model (VSM), and qualitative coding and synthesis in NVivo (Beer, 1985; Bowen, 2009; Krippendorff, 2004; QSR International, 2020).

The unit of analysis is the digital deliberative platform understood as a socio-technical, institutional, and normative system. The analysis focuses on platform architectures, governance arrangements, deliberative procedures, feedback structures, and normative commitments. Broader political and economic conditions are treated as part of the environment of the platform rather than as the primary object of analysis. This delimitation allows comparison across cases that differ substantially in scale, institutional embedding, and technological design while preserving a shared analytical focus (Baxter & Sommerville, 2011; Meadows, 2008; Yin, 2018)

3.1 Case selection

The study analyses seven cases: Cybersyn, Decidim, Loomio, vTaiwan, EUComMeet, MultiPoD, and Consul Democracy. Case selection followed purposive comparative sampling. Four criteria guided inclusion: relevance to digital deliberation or cybernetically informed governance; sufficient availability of public documentation for qualitative analysis; variation in governance model, institutional embedding, and technological design; and analytical usefulness for testing the explanatory value of the VSM across historically and institutionally diverse settings (Bowen, 2009; Yin, 2018).

Cybersyn was included as a historical reference case because it represents an early and influential experiment in cybernetic coordination and recursive governance. The remaining six cases were selected because they reflect different combinations of civic participation, institutionalisation, open-source infrastructure, moderation design, and feedback mechanisms. Taken together, the cases offer sufficient variation to support a structured comparison of functional architecture rather than a claim to representativeness in a statistical sense (Beer, 1985; Yin, 2018).

3.2 Data corpus

The analysis is based on a documentary corpus composed of official platform charters, governance and moderation documents, technical documentation, evaluation reports, academic publications, development plans, archived deliberative materials, and participation metadata. Preference was given to documents that made visible platform architecture, rule systems, implementation pathways, and evidence of learning or adaptation. Because the study is document-based, cases with richer and more stable documentary traces were prioritised (Bowen, 2009).

All documents were imported into NVivo and organised by case and document type. This enabled traceability in coding decisions and supported systematic cross-case comparison. The corpus is not intended to provide exhaustive coverage of every local deployment of the platforms examined, but rather an analytically adequate basis for identifying recurrent functional patterns and systemic asymmetries (QSR International, 2020; Yin, 2018).

3.3 Operationalisation of the VSM coding matrix

To improve methodological transparency, the adapted VSM framework presented in Figure 1 was translated into an explicit coding matrix. In practical terms, each subsystem of the model was treated as a top-level analytical category that structured the document analysis. The coding matrix therefore corresponded directly to the five classical VSM subsystems, supplemented where relevant by System 3 as a distinct audit function, so that the analytical procedure followed the same logic as the conceptual model (Beer, 1985; Espejo & Reyes, 2011)

System 1 captured operational deliberative activity. Passages were coded as System 1 when they referred to concrete participatory practices through which the platform enacted participation, such as proposal submission, online discussion, voting, agenda formation, mini public participation, or other direct forms of deliberative interaction (Beer, 1985). System 2 captured coordination. This category included moderation rules, facilitation procedures, conflict management, interoperability protocols, process alignment, and other mechanisms used to reduce fragmentation and maintain coherence between operational units (Beer, 1985; Espejo & Reyes, 2011).

System 3 captured control and internal regulation. Segments were coded in this category when they described governance structures, administrative oversight, compliance procedures, institutional validation, enforcement mechanisms, or resource allocation that connected platform activity to authoritative decision making (Beer, 1985). System 3 captured audit like functions and was used where the material explicitly referred to independent monitoring, verification, evaluation, or quality control of deliberative processes, especially where reflexive oversight could be analytically distinguished from ordinary governance and administration (Beer, 1985; Espejo & Reyes, 2011).

System 4 captured intelligence, learning, and adaptation. This included strategic analysis, experimentation, scenario building, environmental scanning, the use of analytics, AI supported synthesis, and institutional learning, with passages coded as System 4 when they showed how a platform interpreted changing conditions and adjusted its functioning over time (Beer, 1985; Meadows, 2008). System 5 captured policy, identity, and normative orientation. This category included democratic charters, constitutional principles, ethical commitments, visions of participation, and broader value statements defining the platform's purpose and identity, with passages coded as System 5 when they articulated the normative core through which the platform justified its role in democratic governance (Beer, 1985; Gutmann & Thompson, 1996).

This operationalisation created a one-to-one link between the conceptual model and the coding procedure. Rather than relying on an implicit or ad hoc set of categories, the analysis proceeded through system categories derived directly from the adapted VSM, making explicit what counted as evidence for each subsystem across cases. This structure also prepared the ground for the next stage of analysis, in which these codes were applied in NVivo and compared across cases through matrix coding and thematic synthesis.

Table 1 summarises how the conceptual VSM subsystems were translated into analytical coding categories and specifies the substantive focus of each code in the document analysis (Beer, 1985; Espejo & Reyes, 2011; Espinosa et al., 2023).

Table 1

Mapping of VSM subsystems to analytical coding categories

VSM subsystem	Substantive meaning in this study	Coding focus in document analysis
System 1 – Operations	Concrete deliberative activities and participation units (e.g. online discussions, proposal submission, voting, mini publics) (Beer, 1985).	Passages describing primary participatory practices through which the platform enacts deliberation.
System 2 – Coordination	Mechanisms that stabilise and align operational activities (moderation, facilitation, conflict management, interoperability, process alignment) (Beer, 1985; Espejo & Reyes, 2011).	Passages describing efforts to reduce fragmentation and maintain coherence between deliberative activities.
System 3 – Control	Governance structures, institutional oversight, rule enforcement, compliance, and resource allocation connecting operations to authority (Beer, 1985).	Passages describing how platform activity is governed, regulated, or linked to authoritative decision making.
System 3* – Audit	Independent monitoring, verification, evaluation, and quality control of deliberative processes (Beer, 1985; Espejo & Reyes, 2011).	Passages describing reflexive oversight that can be distinguished from routine administration.
System 4 – Intelligence	Strategic analysis, experimentation, environmental scanning, use of analytics or AI, and institutional learning (Beer, 1985; Meadows, 2008).	Passages describing how platforms interpret changing conditions and adapt their design or procedures over time.
System 5 – Identity	Normative and constitutional commitments defining the platform's democratic role and long-term orientation (Beer, 1985; Gutmann & Thompson, 1996).	Passages articulating values, principles, and visions of participation that justify the platform's existence and role.

Note: *The coding logic can be illustrated with selected platform examples. In Decidim, documents describing participatory processes as structured sequences of phases, including proposal creation, debate, results, evaluation, and monitoring, were coded as System 2 because they referred to mechanisms that coordinate and stabilise deliberative activity across the platform. In vTaiwan, documents describing the collection of online inputs, the synthesis of consultation results, and the subsequent refinement of draft regulations were coded as System 4, because they showed how the system processes information, supports learning, and adapts future action. In Decidim, references to the Social Contract and to democratic guarantees such as transparency, traceability, and open collaboration were coded as System 5, because they expressed the normative commitments that define the platform's identity and democratic purpose.

Together, these definitions and the corresponding codes ensured that the qualitative analysis remained anchored in the VSM framework and made explicit what counted as evidence for each subsystem across the different platforms (Dhakal, 2022).

The coding procedure was directly derived from the adapted VSM framework presented in Figure 1. The five classical VSM subsystems, supplemented where relevant by System 3 as an audit function, were first translated into a coding matrix as top-level analytical categories (Systems 1–5 and 3*). In the analysis, each passage in the documentary corpus was therefore coded to one or more of these six system categories rather than to a separate, ad hoc set of themes. In this way, the coding matrix corresponded one to one to the conceptual model and ensured that the qualitative coding remained anchored in the VSM framework (Beer, 1985; Espejo & Reyes, 2011).

The resulting codebook defined one code for each VSM subsystem and for the audit function (System 3*), specifying for every code a short label, an operational definition, and typical indicators in the documents. Table 1 summarises how each conceptual subsystem was translated into a coding category and what substantive focus guided its application in the analysis.

3.4 Coding procedure and analytical synthesis

The analysis proceeded in four iterative stages. To make the logic of the coding process transparent for readers unfamiliar with qualitative methodology or the Viable System Model, the procedure is explained in some detail below.

In the first stage, all documents were read case by case to identify passages that shed light on how digital deliberative platforms function. The reading focused on descriptions of participation, coordination, governance, feedback, learning, and normative commitments, and served to delimit the segments of text that were relevant for the subsequent analysis (Braun & Clarke, 2006; Krippendorff, 2004).

The second stage applied a theory driven, deductive coding logic. This means that the coding categories were not developed from the data itself but were predefined based on the VSM conceptual framework introduced in Section 2. Concretely, six system codes derived directly from the adapted VSM model were used: System 1 for operational deliberative activity, System 2 for coordination, System 3 for control and internal regulation, System 3 for audit functions, System 4 for intelligence and learning, and System 5 for policy, identity, and normative orientation. Each passage in the documentary corpus was assigned to one or more of these categories, producing a structured functional map of each platform (Beer, 1985; Espejo & Reyes, 2011).

In the third stage, an additional and separate layer of inductive codes was developed. Unlike the VSM categories introduced in the second stage, these codes were not predefined. Instead, they

emerged from repeated reading of the material when patterns appeared that were not captured by the six VSM codes alone. This is an important distinction: the inductive codes do not form a different coding system but complement the deductive VSM structure by naming cross cutting empirical patterns that recurred across multiple cases. These patterns included fragmentation between participation modules, participatory fatigue among citizens, gaps between deliberative outputs and institutional implementation, algorithmic bias in platform design, and structural asymmetries between well-resourced and less resourced participants. Together with the deductive VSM codes, these inductive themes made it possible to describe not only whether a given function was present, but also what systemic problems accompanied or undermined it (Braun & Clarke, 2006).

In the fourth stage, matrix coding queries in NVivo were used to examine how the deductive VSM codes and the inductive themes co-occurred across cases. In practical terms, this meant examining which platforms combined weak coordination (System 2) with themes of fragmentation, or which platforms showed limited intelligence capacity (System 4) alongside persistent implementation gaps. The matrices thus served not to count categories, but to reveal structural relationships between functional architecture and recurring systemic problems across platforms (QSR International, 2020).

Finally, Meadows' leverage point framework was introduced only after this combined deductive and inductive mapping had been completed. It was not used as a coding scheme, but as an interpretative lens to reflect on where within the mapped systems interventions might produce only marginal adjustments and where deeper, more transformative change would be required. In this configuration, the VSM defined the analytical structure, the inductive themes grounded the analysis in recurring empirical patterns, and Meadows' framework guided interpretation of where meaningful change might be located (Beer, 1985; Meadows, 2008).

3.5 Comparative summary of cases

Table 2 summarises the selected cases and the specific aspects of the conceptual framework they help to illuminate, without claiming to offer definitive performance rankings.

Table 2

Comparative summary of the analysed digital deliberative platforms

Case	Type	Institutional setting	Analytical relevance
Cybersyn	Historical cybernetic governance project	State-led coordination	Serves as a historical reference point for thinking about cybernetic governance, feedback, and recursion.
Decidim	Open-source participatory platform	Municipal and civic-institutional	Offers a case for examining how participatory infrastructure, procedural traceability, and explicit democratic commitments can be combined in practice.
Loomio	Collaborative decision platform	Civic/cooperative	Provides an example of locally embedded, cooperative decision making and raises questions about coordination beyond small-scale settings.
vTaiwan	Deliberative process ecosystem	Hybrid civil society-government	Provides a case through which to explore how participation, coordination, institutional response, and iterative learning can be linked over time.
EUComMeet	Deliberative research project	EU research setting	Illustrates how experimental designs in a research context can be used to test different formats of transnational deliberation.
MultiPoD	Multilingual deliberation project	Research and innovation setting	Offers an exploratory example of multilingual and multi-level deliberation across diverse institutional environments.
Consul Democracy	Participatory governance platform	Municipal-administrative	Provides a case for examining how strong institutional embedding interacts with variation in participatory and deliberative practice across implementations.

Table 2 provides a heuristic overview of how the selected cases contribute to the conceptual exploration developed in this article. Because the comparative analysis is based on purposive case selection and documentary material, the formulations in the table should be read as

analytically orienting rather than evaluatively conclusive. These features of the design also point directly to several limitations that need to be acknowledged explicitly.

3.6 Limitations of the design

The credibility of the analysis was strengthened through source triangulation, reflective memoing, and the maintenance of an audit trail in NVivo (Lincoln & Guba, 1985; QSR International, 2020).

At the same time, the design has clear limitations. First, the study relies on documentary material and secondary sources, which means that informal practices, internal negotiations, and actual participant experience cannot be fully captured (Bowen, 2009). Second, platforms such as Decidim and Consul have multiple local implementations, so the analysis identifies general patterns rather than all possible institutional variants (Yin, 2018). Third, although the coding matrix improves transparency, interpretative judgement remains part of the analytical process (Braun & Clarke, 2006; Krippendorff, 2004). Fourth, the selected cases are analytically diverse but not exhaustive, so the findings should be understood as diagnostic and theory-building rather than empirically definitive or universally generalisable (Yin, 2018).

4 Results

4.1 Comparative VSM mapping of the analytical platforms

Applying the VSM as an analytical framework made it possible to identify five core functions across the seven cases: operations, coordination, control, intelligence, and identity. These functions appeared in different ways across platform documents, governance arrangements, and institutional settings, allowing comparison beyond immediately visible technical features. Rather than producing definitive rankings, the analysis highlights varying configurations of the five subsystems and shows how different platforms place emphasis on different dimensions of viability.

Table 3 summarises the comparative VSM mapping of the analysed platforms. The entries in the table are intended as concise functional descriptors derived from the documentary corpus and should be read as heuristic indicators rather than exhaustive empirical judgements.

Table 3

Comparative VSM mapping of the analysed platforms

Platform	S1 Operations	S2 Coordination	S3 Control	S4 Intelligence	S5 Identity
Cybersyn	Factories as operational units	Algedonic signals	Operations room	Simulations	Political project
Decidim	Participatory processes	Moderation and API based coordination	Metadecidim and governance structures	Development community	Democratic charter
Loomio	Autonomous groups	Decision making processes	Minimal supervision	Community learning	Cooperative ethics
vTaiwan	Pol.is and deliberative process design	Algorithmic coordination	Integration with ministries	Digital intelligence	Rough consensus
EUComMeet	Mini publics	Facilitation	Research governance	Experimental learning	European values
MultiPoD	Multi-level groups	Digital coordination	Project management	Experimental approach	Pluralism
Consul Democracy	Budgets and proposals	Moderation	Administrative validation	Global community and platform development	Open-source participation logic

The table 3 indicates that the platforms distribute VSM functions in different ways rather than converging on a single model of digital deliberation. In the available documentation, vTaiwan appears to offer one of the more integrated examples of how operational participation, coordination, institutional uptake, learning, and normative orientation can be linked over time. Decidim presents a comparatively well-articulated combination of participatory infrastructure, governance design, and normative commitments, although the integration of coordination mechanisms and implementation pathways appears more uneven across contexts.

Other cases illuminate different forms of partial viability. Consul Democracy appears relatively more institutionally embedded, especially in relation to administrative validation and formal participation channels, while Loomio is more clearly oriented toward local autonomy,

cooperative decision making, and community-based identity than toward broader system level coordination. EUComMeet and MultiPoD are particularly useful for examining experimental and project-based forms of deliberation, where learning and design innovation are visible but longer-term institutional stabilisation remains less clear. Cybersyn, finally, functions less as a democratic benchmark than as a historically important reference point for analysing coordination, feedback, and recursion in cybernetic terms.

4.2 Systemic asymmetries in platform architecture

At this stage of the analysis, the VSM based comparison is used to identify interpretative analytical patterns in the documentary material rather than to provide definitive comparative findings about the real world performance of the platforms. The tendencies described below should therefore be read as patterns that emerge from the available documents and from the proposed framework, not as empirically validated rankings or exhaustive descriptions of all deployments.

A cross case reading of the seven platforms suggests several recurring systemic asymmetries.

First, System 2 appears as a frequent point of tension in the documentary record. Across several cases, platform documents give substantial attention to participation opportunities at the operational level, while providing comparatively less detailed descriptions of how interactions are coordinated over time and across participation spaces. Coordination procedures, conflict management, and mechanisms for ensuring procedural consistency are often present but described in a more fragmented or ad hoc manner. Within the logic of the VSM, this suggests that the coordination function is weaker formalised than the operational function, especially in platforms that look participatory in form yet exhibit uneven procedural stability across processes.

Second, System 3 is often only partially specified. Many cases include references to governance structures, validation procedures, or formal mandates, but these are not always clearly linked to systematic institutional response capacities. In some instances, documents describe how inputs are collected, sorted, or reviewed, while providing less information on how such inputs are taken up in authoritative decision making or policy change. From a diagnostic perspective, this points to a recurrent gap between deliberative participation and formal implementation, where the control function is more visible on paper than in its concrete effects on institutional responses.

Third, System 4 tends to be less developed than other subsystems in the analysed material. Several platforms refer to forms of strategic reflection, experimentation, data analytics, or algorithmic support, but these elements are frequently presented as auxiliary features rather than as clearly embedded components of a broader learning architecture. Descriptions of how information about past processes feeds into systematic redesign, long term strategy, or adaptive governance are relatively scarce across the corpus. In VSM terms, this suggests that strategic

intelligence is present but often in a more episodic or project bound form, with limited evidence of sustained, institutionalised learning across deliberative cycles. The absence of well formalised System 4 functions also has implications for how platforms handle external shocks, technological change, or shifts in institutional context, since adaptive capacity depends precisely on having mechanisms that can register, interpret, and respond to such changes in a structured way.

Fourth, System 5 is typically normatively explicit but unevenly operationalised. Many platforms foreground democratic values and principles through charters, mission statements, or public codes of conduct. However, the links between such normative commitments and the concrete design of procedures, feedback obligations, or accountability mechanisms are not always fully spelled out in the available texts. This produces a recurrent pattern in which the identity function is strong at the level of declared values, while its translation into systematically organised practices and institutional constraints remains more partial or indirect.

These asymmetries do not imply that the platforms are unviable or ineffective. Rather, they illustrate how the VSM helps to make visible specific areas where functional development appears more advanced alongside areas where institutional arrangements are described in less detail or with greater internal tension. These observations thus serve as starting points for further empirical investigation rather than as final judgements on platform performance.

Potential leverage points for systemic transformation

Building on this diagnostic overview, Meadows' leverage point framework can now be applied as a secondary interpretative lens to reflect on where interventions might produce more than incremental change. This application is explicitly conceptual in character. The leverage points are not proposed here as concrete policy recommendations or as evidence-based prescriptions for specific platforms. Rather, they are offered as a set of analytically grounded prompts for thinking about where redesign efforts might be directed and what depth of intervention different kinds of change would require.

The recurring weakness of System 2 across cases points most directly to leverage points at the level of information flows and rules. In Meadows' terms, improving how feedback circulates within and between deliberative units, and making procedural rules more explicit and enforceable, represents an intervention at a relatively accessible level of the system. Such changes can be introduced without requiring deep institutional transformation and are likely to improve coordination quality, reduce fragmentation, and make deliberative processes more legible to participants.

The partial realisation of System 3, and the recurrent gap between deliberative participation and institutional implementation, points to leverage points at the level of rules and system goals.

Binding accountability obligations for institutional follow up, mandatory response timelines, and clearer linkages between deliberative outputs and decision-making authority would all operate at this level. These interventions are more demanding than information flow adjustments because they require changes to institutional structures and political will rather than technical design alone.

The underdevelopment of System 4 suggests that the most relevant leverage points are located at the level of feedback loops and goals. Embedding systematic evaluation cycles, outcome monitoring, and structured learning processes into platform governance would create the conditions for adaptive intelligence to function not episodically but as a constitutive dimension of the deliberative architecture. This kind of intervention is more difficult to sustain, as it requires resources, organisational capacity, and a long-term institutional commitment to reflexive governance rather than isolated procedural reform.

The gap between declared normative values and their operational embedding in System 5 points to leverage points at the deepest level of Meadows' framework, namely paradigms. Closing this gap does not simply require better procedures or clearer rules. It requires a shift in how institutions understand their relationship to citizens, from viewing participation as a consultative supplement to representative decision making toward treating it as a constitutive feature of legitimate governance. This is the most difficult kind of change to produce and sustain, but it is also the kind of change that, if achieved, would alter the conditions under which all other systemic interventions become meaningful.

Together, this two-step logic, from VSM diagnosis to leverage point reflection, suggests that the improvement of digital deliberative systems is not primarily a technical challenge. It is an institutional and normative challenge that operates at multiple levels of depth simultaneously, and that requires different kinds of intervention depending on where in the system the most consequential gaps are located.

4.3 Feedback loops, delays, and recursive structures

A central result of the analysis concerns feedback loops. In most cases, deliberation generates outputs that move toward institutional review, but information does not return to participants in a timely, transparent, or structured way. This makes feedback largely one-directional and limits the capacity of the platform to sustain trust, learning, and adaptive legitimacy over time.

Table 4 presents a comparative overview of feedback loops, temporal delays, and recursive structures across the analysed platforms, highlighting their implications for responsiveness and systemic learning.

Table 4

Feedback loops, delays, and recursive structures

Platform	Feedback loops	Delays	Recursive structures	Key findings
Cybersyn	Strong operational feedback between factories and centre	Minimal in designed model	Partial: vertical recursion between production units and central control	Cybernetically efficient but not democratically grounded
Decidim	Partial: feedback on proposals and processes, but often uneven	Frequent: institutional responses can be slow or fragmented	Limited: some multi-level use, but not systematically recursive	Normatively strong, operationally, and institutionally uneven
Loomio	Locally strong: groups often close loops internally	Low within small groups	Minimal beyond group level	Strong local learning, but fragmentation at system level
vTaiwan	Bidirectional: institutional responses and public updates are central to the model	Low: relatively short cycles between deliberation and policy response	High: recursive learning across issues and institutions	Best practice for feedback and recursion in the sample
EUComMeet	Designed feedback within project cycles	Moderate: bounded by project timelines	Moderate: connections between local and transnational levels	Methodologically structured, but constrained by project temporality paper.docx
MultiPoD	Experimental feedback between deliberation and design	Moderate	Moderate: potential for multi-level learning	Promising but not yet institutionally stabilised paper.docx
Consul Democracy	Variable: depends strongly on local implementation	Frequent: follow-up is often delayed or unclear	Low: limited support for multi-level recursive learning	Institutionally strong, deliberatively inconsistent

Recursive functionality is comparatively limited across the examined platforms. Most platforms do not clearly connect local, organisational, and higher-level decision processes in a way that would allow learning to circulate across levels. vTaiwan offers the clearest example of recursive functionality because it links deliberative input, issue mapping, public reasoning, and institutional uptake more effectively than the other cases. Decidim contains some recursive potential, particularly through its governance architecture and civic-institutional interface, but this potential is more uneven in practice.

Institutional responsiveness therefore becomes one of the main differentiating variables across cases. Platforms with stronger linkages between deliberation and formal decision-making are better positioned to sustain viability, because they maintain not only participation but also the feedback conditions through which the system can learn from its own outputs. Where these linkages are weak, participation risks becoming episodic, symbolic, or procedurally fragmented.

4.4 Cross-case synthesis

Cross the analysed cases, viability appears to depend not simply on the availability of participatory tools, but on the extent to which participation is integrated into a broader functional architecture. Platforms become more viable when operational participation is coordinated, institutionally linked, supported by learning mechanisms, and anchored in a clear normative orientation. In contrast, platforms become less viable when one subsystem develops in isolation from the others, especially when participation is not matched by coordination, responsiveness, or strategic intelligence.

The comparative pattern across cases can therefore be summarised as follows: operational participation is common, but systemic integration is uneven; coordination is the most frequent weakness; institutional response remains inconsistent; strategic intelligence is often underdeveloped; and normative identity is stronger at the level of declaration than implementation. From this perspective, vTaiwan represents the clearest example of a comparatively balanced digital deliberative system, while other platforms illustrate different forms of partial viability, each with specific strengths and structural limitations.

Table 4 summarises the main systemic strengths, weaknesses, and overall diagnostic profiles of the analysed platforms, condensing the comparative findings into a single overview.

Table 4

Comparative synthesis of systemic strengths and weaknesses across the analysed platforms

Platform	Main strengths	Main weaknesses	Overall diagnostic profile
Cybersyn	Strong coordination and control; powerful feedback for managing complexity	Weak democratic legitimacy and participatory inclusiveness	Illustrates cybernetic viability without democratic viability
Decidim	Clear normative framework; open-source infrastructure; institutional uptake in many cities	Coordination bottlenecks; variable implementation; limited enforcement of deliberative outcomes	Normatively articulated but operationally uneven system
Loomio	Strong local autonomy; cooperative ethos; accessible deliberation for small groups	Limited systemic coordination; weak institutional linkage; fragmented learning	Locally viable deliberative cells without robust system-level integration
vTaiwan	Balanced VSM functions; strong feedback loops; effective institutional responsiveness; robust learning	Dependence on political will; not uniformly institutionalised across policy domains	Most viable digital deliberative ecosystem in the sample
EUComMeet	Carefully designed deliberative formats; attention to inclusion and pluralism; transnational focus	Project-based temporality; limited long-term institutional anchoring	Methodologically strong but institutionally time-bounded model
MultiPoD	Focus on multilingual, multi-level deliberation; experimental learning	Lack of stable institutional embedding; limited scalability beyond projects	Experimental platform with high potential but low institutionalisation
Consul Democracy	Strong administrative integration; wide diffusion; robust control and compliance functions	Feedback loops and deliberative quality vary across deployments; identity often declarative	Institutionally resilient participation infrastructure with partial deliberative viability

Overall, the comparative analysis indicates that the analysed platforms differ substantially in how they combine the functional conditions of viability, ranging from relatively integrated architectures to more partial and uneven configurations. This comparative diagnosis provides the basis for the subsequent discussion, which interprets these patterns in terms of systemic constraints, leverage points for transformation, and implications for the design of digital deliberative systems.

5 Discussion

5.1 VSM as a diagnostic framework for digital deliberative systems

The comparative analysis indicates that the Viable System Model provides a useful diagnostic framework for identifying how digital deliberative platforms organise, coordinate, and stabilise participation across institutional and technological settings (Beer, 1985; Espejo & Reyes, 2011). Its main analytical value lies in distinguishing between the presence of participatory activity and the broader functional conditions required for systemic viability (Beer, 1985). In this respect, the results suggest that many platforms succeed in enabling participation at the operational level, but fewer achieve a balanced integration of coordination, control, strategic learning, and normative orientation.

This finding is particularly important because it clarifies that viability cannot be reduced to participation volume, technical sophistication, or normative aspiration alone. Rather, viability depends on how these dimensions are connected through a coherent functional architecture (Beer, 1985; Meadows, 2008). The recurrent weaknesses identified in coordination, institutional responsiveness, and strategic intelligence indicate that many digital deliberative systems remain only partially viable: they support engagement, but do not consistently transform engagement into adaptive and institutionally consequential democratic processes.

The results also reinforce the analytical usefulness of distinguishing among the five VSM subsystems. System 2 emerged as the most frequent bottleneck, showing that coordination remains a decisive but underdeveloped condition of deliberative quality. System 3 proved equally important, because the absence of robust institutional follow-up often leaves deliberative outputs weakly connected to decision-making. System 4 was present unevenly, suggesting that many platforms lack sufficient capacity for reflexive learning, environmental scanning, and long-term adaptation. System 5, finally, was often strongly articulated in normative terms, but more unevenly realised in practice (Beer, 1985; Espejo & Reyes, 2011; Meadows, 2008).

These patterns support the argument that the VSM helps reveal structural constraints that are not immediately visible through conventional evaluations of participation platforms. Instead of assessing platforms only by user access, formal openness, or technological novelty, the VSM makes it possible to examine whether the system can maintain coherence, learn from feedback,

and sustain democratic purpose under conditions of complexity (Beer, 1985; van Der Heijden, 2022).

5.2 Meadows lever points as an interpretative framework for transformation

If the VSM helps diagnose systemic architecture, Meadows' leverage points help interpret where meaningful transformation is most likely to occur (Meadows, 2008). The comparative findings suggest that many of the identified weaknesses are not merely technical deficiencies, but signs of deeper problems in information flows, rule structures, institutional goals, and governing assumptions. From this perspective, digital deliberative platforms do not fail only because they lack better tools, but because they often operate within weakly aligned institutional logics (Meadows, 2008; OECD, 2022).

The most immediate leverage point concerns information flows. The results showed that feedback is frequently one-directional: proposals move upward toward institutional review, but implementation information often fails to return to participants in a timely and intelligible form. This weakens trust, undermines learning, and reduces the perceived legitimacy of participation. Improving information flows would therefore not be a minor procedural adjustment, but a systemic intervention capable of strengthening both responsiveness and adaptive capacity (Meadows, 2008; Pentland & Tsai, 2024).

A second leverage point concerns system rules. Where moderation procedures, institutional response obligations, and implementation pathways remain unclear or inconsistent, platform viability is weakened even when participation is formally open. The findings suggest that more explicit procedural rules could improve coherence across operational units and reduce fragmentation. In this sense, governance rules are not peripheral design details, but core conditions for maintaining democratic functionality in complex digital settings (Meadows, 2008; OECD, 2022).

A deeper level of transformation concerns system goals and paradigms. The comparative analysis suggests that platforms become more viable when participation is treated as an ongoing learning process rather than a sequence of isolated consultative events. vTaiwan is the clearest example in the sample because it combines iterative deliberation, institutional uptake, and visible feedback in a comparatively integrated way. This indicates that the most consequential reforms may depend less on adding new participation tools than on reorienting the goals of digital democracy toward recursion, responsiveness, and co-governance (Beer, 1985; Meadows, 2008; vTaiwan, n.d.).

5.3 From diagnosis to transformation: leverage points in digital deliberative systems

Building on this diagnostic overview, Meadows' leverage point framework can now be applied as a secondary interpretative lens to reflect on where interventions might produce more than

incremental change. This application is explicitly conceptual in character. The leverage points are not proposed here as concrete policy recommendations or as evidence-based prescriptions for specific platforms. Rather, they are offered as a set of analytically grounded prompts for thinking about where redesign efforts might be directed and what depth of intervention different kinds of change would require.

The recurring weakness of System 2 across cases points most directly to leverage points at the level of information flows and rules. In Meadows' terms, improving how feedback circulates within and between deliberative units, and making procedural rules more explicit and enforceable, represents an intervention at a relatively accessible level of the system. Such changes can be introduced without requiring deep institutional transformation and are likely to improve coordination quality, reduce fragmentation, and make deliberative processes more legible to participants.

The partial realisation of System 3, and the recurrent gap between deliberative participation and institutional implementation, points to leverage points at the level of rules and system goals. Binding accountability obligations for institutional follow up, mandatory response timelines, and clearer linkages between deliberative outputs and decision-making authority would all operate at this level. These interventions are more demanding than information flow adjustments because they require changes to institutional structures and political will rather than technical design alone.

The underdevelopment of System 4 suggests that the most relevant leverage points are located at the level of feedback loops and goals. Embedding systematic evaluation cycles, outcome monitoring, and structured learning processes into platform governance would create the conditions for adaptive intelligence to function not episodically but as a constitutive dimension of the deliberative architecture. This kind of intervention is more difficult to sustain, as it requires resources, organisational capacity, and a long-term institutional commitment to reflexive governance rather than isolated procedural reform.

The gap between declared normative values and their operational embedding in System 5 points to leverage points at the deepest level of Meadows' framework, namely paradigms. Closing this gap does not simply require better procedures or clearer rules. It requires a shift in how institutions understand their relationship to citizens, from viewing participation as a consultative supplement to representative decision making toward treating it as a constitutive feature of legitimate governance. This is the most difficult kind of change to produce and sustain, but it is also the kind of change that, if achieved, would alter the conditions under which all other systemic interventions become meaningful.

Together, this twostep logic, from VSM diagnosis to leverage point reflection, suggests that the improvement of digital deliberative systems is not primarily a technical challenge. It is an

institutional and normative challenge that operates at multiple levels of depth simultaneously, and that requires different kinds of intervention depending on where in the system the most consequential gaps are located.

5.4 Answer to the research question

The research question asked how and to what extent the Viable System Model, strengthened by Meadows' leverage point perspective, can offer actionable and systematic guidance for transforming digital democratic systems in ways that enhance resilience, adaptability, and inclusiveness. The analysis suggests that the combined framework does provide such guidance, but primarily in a diagnostic and strategic sense rather than as a fixed design template (Beer, 1985; Meadows, 2008). It helps identify where digital deliberative systems are structurally imbalanced and where interventions are most likely to improve their long-term viability.

More specifically, the VSM clarifies that resilient and inclusive digital deliberation depends on the integration of operational participation with coordination, institutional control, strategic intelligence, and normative identity (Beer, 1985; Espejo & Reyes, 2011). Meadows' framework complements this by indicating that the most effective interventions are likely to involve the redesign of feedback channels, procedural rules, institutional commitments, and the underlying goals of participation (Meadows, 2008; OECD, 2022).

The two frameworks support a move from descriptive analysis toward a theory of intentional transformation through a specific two step logic. In the first step, the VSM is used to map the functional architecture of a platform and identify which subsystems are present, which are weak, and which are structurally disconnected from each other. This diagnostic step produces a differentiated picture of where viability is compromised and why. In the second step, Meadows' leverage point framework is applied to translate this diagnosis into a ranked account of intervention priorities. Since leverage points differ in depth, from parameter adjustments at the surface to paradigm shifts at the core, the framework allows practitioners and researchers to distinguish between changes that are easy to implement but likely to produce limited effects, and changes that are more demanding but potentially transformative. Applied together, the two frameworks thus make it possible to move beyond the observation that a platform is "weak in coordination" or "lacking in strategic intelligence," and to ask instead: at what level of the system does the problem originate, what kind of intervention would be required to address it, and which changes are likely to have the most consequential effects on democratic quality over time (Beer, 1985; Meadows, 2008; Espejo & Reyes, 2011).

The contribution of this framework is therefore not that it offers a universal model applicable in identical form across all settings. Rather, its value lies in providing a structured way to diagnose variation, compare platform architectures, and identify reform priorities in context sensitive ways (Yin, 2018). In this sense, the study supports the view that digital deliberation becomes more

viable not when platforms simply accumulate features, but when they are organised as learning systems capable of feedback, coordination, adaptation, and democratic justification (Beer, 1985; Gutmann & Thompson, 1996; Meadows, 2008).

5.5 Critical reflections

At the same time, the discussion points to several cautions in applying the VSM to digital democracy. The analytical strength of the model lies in its structural clarity, but this same clarity can also obscure dimensions of power, inequality, and political struggle that are central to democratic life. A platform may appear functionally coherent while still reproducing exclusion, unequal influence, or weak public accountability. For this reason, the VSM should not be treated as a self-sufficient theory of democracy, but as a systems-analytical framework that must remain connected to deliberative and institutional theory (Gutmann & Thompson, 1996; Habermas, 1996; Jiménez-Pernett et al., 2023).

A second caution concerns the documentary and interpretative basis of the analysis. The comparative findings identify recurring functional patterns, but they do not fully capture informal practices, implementation variation, or participant experience. This is particularly relevant for widely distributed platforms such as Decidim and Consul Democracy, whose local instantiations may differ substantially. The conclusions should therefore be understood as theory-building and diagnostically robust, but not as exhaustive empirical evaluations of all deployments (Bowen, 2009; Yin, 2018).

A third caution concerns temporal change. Digital deliberative systems evolve quickly as platform features, governance arrangements, and political contexts shift. What appears as a stable subsystem relation in one period may be altered by later redesign, institutional change, or technological adaptation. This reinforces the value of the framework as a dynamic diagnostic instrument but also underlines the need for future longitudinal and implementation-based research (European Commission, JRC, 2025; Yin, 2018).

6 Conclusion

6.1 Concluding remark

This article has argued that digital deliberative platforms are productively understood not simply as participatory tools, but as complex socio-technical systems whose viability can be theoretically associated with the integration of operational participation, coordination, control, strategic learning, and normative orientation (Beer, 1985; Baxter & Sommerville, 2011; Meadows, 2008). By combining the Viable System Model with Meadows' leverage point perspective, the study developed a structured analytical framework for identifying interpretative patterns of systemic weakness and for reflecting on where intervention efforts might be directed in the design and governance of digital deliberative systems.

The comparative analysis suggests that many platforms provide meaningful opportunities for participation, yet fewer appear to display a comparatively balanced configuration across the five functional dimensions associated with viability in the proposed framework. Coordination emerged as a frequent point of tension in the documentary material, institutional responsiveness appeared unevenly developed, strategic intelligence tended to be described in more episodic than constitutive terms, and normative identity was typically more explicit at the level of declared values than in its operational embedding. Among the analysed cases, vTaiwan can be interpreted as offering one of the more integrated examples of how operational participation, coordination, institutional uptake, and iterative learning can be connected over time, while the other platforms illustrated different configurations of partial viability, each with analytically distinct strengths and less developed areas.

In response to the research question, the analysis indicates that the combination of the VSM and Meadows' leverage points can offer analytically grounded and systematic guidance for thinking about the transformation of digital democratic systems, primarily as a diagnostic and strategic framework rather than as a universal design model (Beer, 1985; Espejo & Reyes, 2011; Meadows, 2008). Its main value lies in providing a theoretically structured way to identify where functional imbalances appear to arise, how these imbalances may affect democratic performance, and which kinds of interventions are most likely to strengthen resilience, adaptability, inclusiveness, and legitimacy across diverse institutional contexts.

6.2 Research limitations

Several limitations should be considered when interpreting the findings. First, the study is conceptually and theoretically oriented and relies on documentary analysis rather than direct observation of deliberative practice. It therefore does not fully capture informal interactions, implementation dynamics, or the lived experience of participants within digital deliberative systems (Bowen, 2009; Yin, 2018).

Second, the analysed platforms differ substantially in institutional setting, scale, and maturity, and some of them—especially Decidim and Consul Democracy—exist in multiple local implementations. The analysis therefore identifies broad functional patterns rather than providing exhaustive empirical evaluation of all platform variants. Third, although the VSM coding matrix improves analytical transparency, the interpretation of platform functions still depends partly on theoretical judgement and comparative abstraction (Braun & Clarke, 2006; Espejo & Reyes, 2011; QSR International, 2020)

A further limitation concerns temporality. Digital platforms evolve rapidly as governance arrangements, user practices, and technical infrastructures change. Some findings may therefore lose precision over time, particularly in relation to platform redesign, algorithmic features, and institutional uptake. For this reason, the study should be read as a theory-building

contribution with comparative diagnostic value rather than as a final or static assessment of platform viability (European Commission, JRC, 2025; Yin, 2018).

6.3 Recommendations for practice

The following recommendations are derived from the interpretative and theory building orientation of the framework rather than from direct empirical evaluation of implementation outcomes. They are therefore intended as analytically grounded starting points for reflection and design rather than as prescriptions with universal applicability. Their relevance and feasibility will vary substantially depending on institutional context, available resources, governance culture, and the degree of political and administrative commitment to participatory governance.

The first priority is to strengthen coordination mechanisms. In the analysed material, System 2 appeared as a frequent point of tension, particularly in platforms operating across multiple participation spaces or administrative levels. For public administrations and platform designers working in institutionally fragmented settings, this implies investing in clearer moderation protocols, more consistent process rules, and stronger alignment between deliberative stages. In smaller scale or civic cooperative settings, where coordination tends to be more informal, the priority may instead be to make existing informal practices more legible and transferable (Beer, 1985; OECD, 2022).

A second priority is to institutionalise feedback loops between deliberation and institutional response. Many platforms in the analysed corpus invite participation but provide limited structured information about what happens once a deliberative cycle concludes. Where platforms are embedded in formal public administrations, this points to the need for binding response timelines, publicly visible implementation tracking, and regular structured reporting back to participants. Where platforms operate in more project based or experimental contexts, lighter forms of structured synthesis and follow up communication may be more realistic and appropriate (Beer, 1985; Meadows, 2008).

A third priority is to integrate strategic intelligence more effectively into governance arrangements. Data analytics, experimental modules, and digital feedback tools tend to function in the analysed cases as peripheral technical features rather than as constitutive elements of adaptive governance. Making these functions more systematically embedded requires not only technical capacity but also institutional mandates for evaluation, willingness to act on learning, and sufficient organisational stability to sustain reflection across deliberative cycles. These conditions are more readily available in well-resourced national or supranational settings than in smaller municipal or project based deployments, which suggests that the depth of this reform will necessarily vary across governance levels (Meadows, 2008).

A fourth priority is to translate normative commitments into operational design. Democratic values such as inclusion, transparency, accountability, and reciprocity are most effective when embedded not only in charters and mission statements but also in concrete moderation rules, institutional procedures, and algorithmic design choices. This translation is challenging because it requires ongoing dialogue between normative principles and technical implementation, and because it depends on institutional actors being willing to accept constraints on their discretion in the name of democratic consistency (Beer, 1985; Gutmann & Thompson, 1996).

Finally, platforms are likely to become more democratically effective when they are developed as recursive infrastructures rather than isolated participation events, with stronger functional connections across local, organisational, and higher governance levels where such connections are institutionally feasible. This recommendation is most relevant for platforms embedded in multi-level governance systems, such as those operating across European, national, and municipal levels, and less immediately applicable to purely local or project bound deployments. In all cases, however, the underlying orientation remains the same: deliberation becomes more viable when it is organised as a continuous learning process rather than as a series of disconnected consultative episodes (Gutmann & Thompson, 1996; OECD, 2022).

6.4 Future research

Future research should extend this framework in several directions. First, longitudinal empirical studies are needed to examine how platform viability changes over time and how subsystem relations evolve under shifting political, organisational, and technological conditions. Such work would help test whether coordination, feedback, and learning capacities can be stabilised in practice, rather than only identified analytically (Beer, 1985; Meadows, 2008; Yin, 2018).

Second, more implementation-oriented and ethnographic research is needed to investigate moderation practices, informal power relations, and participant experiences within digital deliberative settings. This would provide a richer understanding of how democratic norms are enacted, contested, or undermined in practice, especially under conditions of asymmetry and institutional inequality (Gutmann & Thompson, 1996; Habermas, 1996; Jiménez-Pernett et al., 2023).

Third, future studies should examine recursive and multi-level deliberative architectures more systematically, particularly in transnational and multilevel governance settings such as the European Union. Additional research is also needed on the relationship between algorithmic mediation, deliberative equality, and institutional legitimacy, especially where digital tools shape visibility, clustering, prioritisation, or consensus formation (European Commission, JRC, 2025; Pentland & Tsai, 2024). Finally, the proposed framework should be empirically validated across different political and cultural environments to refine the concept of viability and test its usefulness as a comparative analytical tool.

References

1. Alnemr, N. (2025). Deliberative democracy in an algorithmic society: Harms, contestations and deliberative capacity in the digital public sphere. *Democratization*, In press.
2. Ashby, W. R. (1958). Requisite variety and its implications for the control of complex systems. *Cybernetica*, 1(2), 83–99.
3. Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, 23(1), 4–17.
4. Beer, S. (1979). *The heart of enterprise*. Wiley.
5. Beer, S. (1981). *Brain of the firm* (2nd ed.). Wiley.
6. Beer, S. (1985). *Diagnosing the system for organisations*. Wiley.
7. Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27–40.
8. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
9. Cheng, A., & Godel, M. (2021). *vTaiwan: Collective intelligence for digital democracy*. Nesta.
10. Dhakal, K. (2022). NVivo. *Journal of the Medical Library Association*, 110(2), 270.
11. Decidim. (2026). *Decidim: Free open-source participatory democracy for cities and organisations*. <https://decidim.org>
12. DigWatch. (2026, May 25). *Argentina launches AI 'Digital Twin' system for social policy planning*. Geneva Internet Platform. <https://dig.watch/updates/argentina-predictive-ai-social-policy-planning>
13. Espejo, R. (2022). Cybersyn, big data, variety engineering and governance. *AI & Society*, 37(3), 1163–1177.
14. Espejo, R., & Reyes, A. (2011). *Organizational systems: Managing complexity with the viable system model*. Springer.
15. Espinosa, A. M., Walker, J., & Martinez-Lozada, A. C. (2023). The Viable System Model: An introduction to theory and practice. *Journal of Systems Thinking*, 3(1), 1–19.
16. Espinosa, A. (2025). Revisiting the Viable System Model as an emancipatory systems approach. *Systems Research and Behavioral Science*, 42(1), 171–188.
17. EUComMeet. (2024). *EUComMeet: Deliberative spaces for democracy*. <https://www.eucommeet.eu/>
18. Eurocities. (2024, December 22). *Urban digital twins: Transforming city planning and governance*. <https://eurocities.eu/latest/urban-digital-twins-transforming-city-planning-and-governance/>
19. European Commission. (2026). *AI Act: The EU's new rules for artificial intelligence*. <https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai>
20. European Commission, Joint Research Centre. (2025). *Harnessing innovation in online deliberation*. Publications Office of the European Union. <https://publications.jrc.ec.europa.eu/repository/handle/JRC139951>
21. European Data Protection Supervisor. (November 14, 2022). *EU-wide cybersecurity requirements to protect privacy and personal data*. https://www.edps.europa.eu/press-publications/press-news/press-releases/2022/eu-wide-cybersecurity-requirements-protect-privacy-and-personal-data_en

22. European Union. (2016). *Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016, on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)*. <https://www.legislation.gov.uk/eur/2016/679/contents>
23. European Union. (2022). *Directive (EU) 2022/2555 of the European Parliament and of the Council of December 14, 2022, on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive)*. <https://www.nis-2-directive.com>
24. European Union. (2024). *Regulation (EU) 2024/1689 of the European Parliament and of the Council of June 13, 2024, laying down harmonised rules on artificial intelligence*. <https://www.springlex.eu/en/packages/ai-act/ai-act-regulation/>
25. Fischli, R., & Muldoon, J. (2024). *Platform democracy: Digital infrastructure and democratic governance*. Oxford University Press.
26. Fishkin, J., Bolotnyy, V., Lerner, J., Siu, A., & Bradburn, N. (2025). Scaling dialogue for democracy: Can automated deliberation create more deliberative voters?. *Perspectives on Politics*, 23(2), 434-451.
27. Fung, A. (2015). Putting the public back into governance: The challenges of citizen participation and its future. *Public Administration Review*, 75(4), 513-522. <https://doi.org/10.1111/puar.12361>
28. Gutmann, A., & Thompson, D. (1996). *Democracy and disagreement*. Harvard University Press
29. Habermas, J. (1996). *Between facts and norms: Contributions to a discourse theory of law and democracy* (W. Rehg, Trans.). MIT Press.
30. Jiménez-Pernett, J., Lehoux, P., Olry-de-Labry, A., & Bermudez-Tamayo, C. (2023). Accounting for power imbalances in online public deliberations. a systematic review of asymmetry measures. *Health Policy and Technology*, 12(1), 100721.
31. Kennedy, R., Sokhey, A. E., Abernathy, C., Esterling, K. M., Lazer, D. M. J., Lee, A., Minozzi, W., & Neblo, M. A. (2020). Demographics and (equal?) voice: Assessing participation in online deliberative sessions. *Political Studies*, 69(1), 66-88.
32. Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2nd ed.). SAGE.
33. Laouris, Y., & Tuddenham, P. (2025). Revitalizing democracy through cybernetics and systems science: Principles and applications for effective governance. *Futures*, 103693.
34. Le Blanc, D. (2020). *E-participation: A quick overview of recent qualitative trends (DESA Working Paper No. 163, ST/ESA/2020/DWP/163)*. United Nations, Department of Economic and Social Affairs. https://www.un.org/esa/desa/papers/2020/wp163_2020.pdf
35. Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE.
36. Loomio. (n.d.). *Loomio*. <https://www.loomio.com/>
37. Maturana, H., & Varela, F. (1987). *The tree of knowledge: The biological roots of human understanding*. Shambhala.
38. Meadows, D. H. (2008). *Thinking in systems: A primer*. Chelsea Green Publishing.
39. Medina, E. (2011). *Cybernetic revolutionaries: Technology and politics in Allende's Chile*. MIT Press.
40. Mikhaylovskaya, A. (2024). Enhancing deliberation with digital democratic innovations. *Philosophy & Technology*, 37(1), 3.
41. MultiPoD. (2025). *MultiPoD: Multilingual and multicultural spaces for political deliberation*. <http://multipod-project.eu/>

41. NextMSC. (2026, May 27). *Argentina launches AI policy: Digital twin market update*. Next Move Strategy Consulting. <https://www.nextmsc.com/news/argentina-launches-ai-policy-digital-twin-market-update>
42. OECD. (2022). *OECD guidelines for citizen participation processes*. OECD Publishing. https://www.oecd.org/en/publications/oecd-guidelines-for-citizen-participation-processes_f765caf6-en.html
43. OECD. (2024). *Innovative citizen participation and new democratic institutions: Catching the deliberative wave*. OECD Publishing. <https://doi.org/10.1787/339306da-en>
44. OECD Observatory of Public Sector Innovation. (2025, January 29). *vCity: A human-centric platform for urban digital twins*. <https://oecd-opsi.org/innovations/vcity-a-human-centric-platform-for-urban-digital-twins/>
45. Pentland, A., & Tsai, L. (2024). Toward building deliberative digital media: From subversion to consensus. *PNAS Nexus*, 3(10), pgae407.
46. Pickering, A. (2010). *The cybernetic brain: Sketches of another future*. University of Chicago Press.
47. QSR International. (2020). *NVivo qualitative data analysis software* (Version 12). QSR International.
48. Raes, L., Concilio, G., Doran, C., Temmerman, L., & Crompvoets, J. (2025). Local digital twins for smart cities: Opportunities for evidence-informed decision-making. In G. Concilio, C. Doran, & J. Crompvoets (Eds.), *Decide better: Open and interoperable local digital twins* (pp. 33–58). Springer Nature Switzerland.
49. Romberg, J., & Escher, T. (2024). Making sense of citizens' input through artificial intelligence: A review of methods for computational text analysis to support the evaluation of contributions in public participation. *Digital Government: Research and Practice*, 5(1), Article 3.
50. Tessler, V., Bakker, M., & Heersmink, R. (2024). Artificial intelligence and democratic deliberation. *AI & Society*, 39(2), 555–570.
51. Sadat, A. (2025). Digital governance and civic inclusion to enhance public participation. *Frontiers in Political Science*, 7, 1671373.
52. Tessler, M. H., Bakker, M. A., Jarrett, D., Sheahan, H., Chadwick, M. J., Koster, R., ... & Summerfield, C. (2024). AI can help humans find common ground in democratic deliberation. *Science*, 386(6719).
53. van Der Heijden, J. (2022). The value of systems thinking for and in regulatory governance: An evidence synthesis. *Sage Open*, 12(2), 21582440221106172.
54. vTaiwan. (n.d.). vTaiwan. <https://info.vtaiwan.tw/>
55. Wagenaar, H. (2022). *Meaning in action: Interpretation and dialogue in policy analysis* (2nd ed.). Routledge. Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE.

Conflict of Interest

The authors declare no conflict of interest (OR specify any conflicts)

Ethics Statement

Ethics approval was not required for this study, as it involves no empirical research with human participants. The analysis draws exclusively on publicly available documents and secondary sources, and no personal data was collected or processed.

AI Statement

Artificial intelligence (AI) tools were used in the preparation of this manuscript in a limited and supplementary capacity. Specifically, Claude Sonnet 4.6 (Anthropic) was used to support language editing, structural suggestions, and clarity improvements during the drafting process. Grammarly was additionally used for grammar, spelling, punctuation, and style checking throughout the manuscript. All AI-generated content was reviewed and edited by the authors, who take full responsibility for the integrity and accuracy of the final manuscript. AI tools were not listed as authors, and their use complies with the COPE (2023) and APA (2025) guidelines on ethical authorship and transparency.

Vasja Roblek is a doctoral student at the Faculty of Organisation Studies in Novo mesto. He is specialising in participatory governance, digital democracy, and institutional transformation. His research focuses on the design and evaluation of digital and procedural mechanisms for citizen participation in municipal decision-making.

Povzetek

Vzdržni sistemski model in digitalna deliberativna demokracija: kibernetski okvir za odpornost, vključenost in prilagodljivost

Raziskovalno vprašanje (RV): Kako in v kolikšni meri lahko Model viable sistema (VSM), okrepljen s perspektivo vzvodnih točk Donelle Meadows, ponudi uporabna in sistemska priporočila za preoblikovanje digitalnih demokratičnih sistemov z namenom krepitve njihove odpornosti, prilagodljivosti in vključenosti?

Namen: Namen raziskave je usmerjen v razvoj analitičnega in transformativnega ogrodja namenjenega diagnosticiranju strukturnih slabosti digitalnih platform. Hkrati ogrodje zagotavlja tudi opredelitev intervencijskih točk. Njihova naloga je, da omogočijo prehod od digitalne participacije kot tehničnega ogrodja k digitalni deliberaciji kot vzdržnemu, rekurzivnemu in učečemu se demokratičnemu sistemu.

Metoda: Teoretični pristop, ki vključuje vsebinski pregled literature in strukturirano analizo sedmih primerov platform. Kot kodirna matrika je bil uporabljen VSM. V procesu so bile kartirane platforme po petih podsistemih. Medtem, ko so bile Meadowsove vzvodne točke uporabljene kot hevristično orodje za opredelitev transformativnih intervencij. Kvalitativno kodiranje in sinteza sta bila izvedena z NVivo.

Rezultati: Iz analize je razvidno, da večina platform trpi za asimetričnim razvojem podsistemov. Tako koordinacija (S2) predstavlja največkrat ozko grlo. Razvidno je tudi, da je strateška inteligenca (S4) premalo integrirana, medtem ko normativna identiteta (S5) pogosto ostaja na deklarativni ravni. Povratne zanke so večinoma enosmerne in rekurzivne strukture redke. Med platformami izstopa vTaiwan. Gre za dober primer iz prakse, ki je dosledno implementiral vse VSM funkcije in ima razvito bidirekcijske povratne zanke.

Organizacija: Ugotovitve raziskave so uporabne za razvijalce platform, občinske uprave in javne institucije v okviru razvoja bolj odpornih in legitimnih digitalnih participativnih sistemov. V okviru priporočil so podani standardizirani moderacijski protokoli, vzpostavljeni so zavezujoči se mehanizmi

institucionalnega odziva. Vključena je tudi integracija strateških analitičnih orodij v upravljalvske procese.

Družba: Rezultati raziskave prispevajo k razumevanju možnosti krepitve demokratične legitimnosti s strani digitalnih deliberativnih platform. Predvsem je potrebno izpostaviti vključenost marginalnih skupin in pomen zaupanja v institucije. V okviru študije so obravnavana tudi tveganja algoritmičnih pristranskosti, dezinformacij in neenakosti dostopa do informacij. Za vse te izzive pa je potrebno oblikovati regulativne okvirje na rani EU in posameznih držav.

Originalnost: Originalnost prispevka je v sistematičnem povezovanju VSM in Meadowsovih vzvodnih točk kot integriranega dvostopenjskega ogrodja za analizo digitalnih deliberativnih sistemov. VSM je že bil apliciran na organizacijske sisteme, medtem ko kombinacija le tega z Meadowsovo teorijo intervencijskih točk v okvir digitalne demokracije predstavlja novo analitično paradigmo.

Omejitve/nadaljnje raziskovanje: Primarna omejitev študije leži v teoretični naravi raziskave, ki ne vključuje empiričnega testiranja ogrodja v okviru institucionalnih okolij. Sama dinamičnost digitalnih platform in vse hitrejši tehnološki razvoj omejujeta posploševanje ugotovitev. Potrebno bi bilo empirično validirati ogrodje v realnih digitalnih deliberativnih procesih. Potrebno je pripraviti longitudinalne študije platform in komparativno analizo v okviru različnih kulturnih in institucionalnih okoljih.

Ključne besede: digitalna deliberativna demokracija, vzdržni sistemski model, vzvodne točke, kibernetika, upravljanje, povratne zanke, spletne participativne platforme, digitalna demokratična inovacija.



Articles in this journal are licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).



Fakulteta za
organizacijske študije
Faculty of organisation studies

This journal is published by [Faculty of Organisation Studies in Novo mesto](https://www.fos.unm.si/).

Delovne obremenitve v dobi umetne inteligence: raziskovalni trendi

Tilen Medved ¹  , Zvone Balantič ²  

¹ Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija 

² Univerza v Mariboru, Fakulteta za organizacijske vede, Slovenija

Povzetek

Raziskovalno vprašanje (RV): Kako se je raziskovanje na področju umetne inteligence in delovnih obremenitev razvijalo skozi čas in katere teme, metode in vrzeli oblikujejo sedanje razumevanje delovnih obremenitev in dobrega počutja pri delu, ki ga omogoča umetna inteligenca?

Namen: Namen te študije je opisati in vizualno prikazati raziskovalno področje umetne inteligence in delovnih obremenitev ter identificirati ključne teme, trende objavljanja in vrzeli, ki so pomembne za oblikovanje dela, upravljanje in dobro počutje.

Metoda: Študija uporablja bibliometrično analizo za recenzirane publikacije, indeksirane v Scopusu v zadnjih petih letih. Pregledna strategija iskanja zajema umetno inteligenco, delovne obremenitve in povezane pojme. Analiza preučuje rast publikacij, vzorce citiranja, mreže virov in avtorjev ter sočasno pojavljanje ključnih besed, podprto s tehnikami znanstvene vizualizacije. Interpretacija temelji na perspektivah oblikovanja dela in zahtevah dela.

Rezultati: Zaznali smo izrazito rast objav na področjih umetne inteligence in delovnih obremenitev ter visoko interdisciplinarnost področja. Prispevek predstavlja prevladujoče raziskovalne teme, koncentracijo raziskav v povezavi z regijami. Prikazani so metodološki vzorci in področja delovnih obremenitev, ki so v povezavi z umetno inteligenco premalo raziskana.

Organizacija: S sintezo razdrobljenega sklopa raziskav, študija pomaga menedžerjem in kadrovskim strokovnjakom razumeti, kje so dokazi o pozitivni rabi umetne inteligence dobro razviti in kje je pri uvajanju umetne inteligence v delovne procese potrebna previdnost ali poglobljena ocena.

Družba: Interpretacija obravnave delovnih obremenitev v raziskavah povezanih z umetno inteligenco, prispeva k njeni odgovorni rabi. Zavedati se moramo, da gre za zdravje zaposlenih na podlagi jasne in zanesljive presoje. Stremeti je potrebno k pravičnim delovnim praksam v vse bolj avtomatiziranih okoljih.

Originalnost: Študija ponuja osredotočen bibliometrični pregled raziskav delovnih obremenitev, povezanih z umetno inteligenco. Izhajamo iz interdisciplinarne obravnave oblikovanja dela, stresa in dobrega počutja.

Omejitve/nadaljnje raziskovanje: Bibliometrični izsledki so odvisni od obsega ene same zbirke podatkov in izbire iskanja ter ne zagotavljajo vzročnih dokazov. Prihodnje raziskave bi morale združiti bibliometrično raziskovanje z empiričnimi in intervencijskimi študijami v različnih sektorjih in regijah.

Ključne besede: umetna inteligenca, delovne obremenitve, zahteve dela, poklicni stres, oblikovanje dela, dobro počutje zaposlenih, bibliometrična analiza.

1 Uvod

Raziskovanje na področju umetne inteligence (UI) in delovnih obremenitev se je skozi čas razvijalo od preučevanja avtomatizacije posameznih nalog k celostnemu razumevanju vpliva UI na dinamiko dela in dobro počutje zaposlenih.

UI spreminja način dela: vpliva na hitrost izvajanja nalog, razporeditev dela, podporo odločanju, nadzor ter način merjenja in poročanja o učinkovitosti. V praksi to pogosto pomeni, da UI ne »odstrani« obremenitev, temveč jih preusmeri (npr. v nadzor izjem, obravnavo napak, usklajevanje s sistemom in poročanje). To se ujema z ugotovitvami evropskih analiz digitalizacije dela, ki kažejo mešane učinke: manj fizičnih tveganj in rutine, hkrati pa več intenzivnosti dela, več časovnega pritiska in tveganj »vedno dosegljivosti« (González Vázquez et al., 2024).

V evropskem okviru Industrije 5.0 je izpostavljeno načelo, da mora tehnologija podpirati človeka, trajnost in odpornost, pri čemer se dobro počutje delavca postavi v središče proizvodnje in storitev (Breque et al., 2021). Vzporedno se razvija tudi pravni okvir za odgovorno uporabo UI. Uredba (EU) 2024/1689 o umetni inteligenci je začela veljati 1. avgusta 2024, njene določbe pa se uporabljajo postopno; večina uredbe se uporablja od 2. avgusta 2026 (Uredba (EU) 2024/1689). Na ravni Slovenije, Vlada Republike Slovenije, v strategiji NsUI 2030, izrecno poudari »človeku prijazno« in zaupanja vredno uvajanje UI ter povezavo z evropskimi usmeritvami (Vlada Republike Slovenije, 2026).

V tem kontekstu postane vprašanje delovne obremenitve ključno tudi za odgovorno upravljanje UI: če organizacije merijo le učinkovitost, lahko spregledajo dvig mentalne obremenitve, stres in posledice za zdravje ter varnost pri delu (González Vázquez et al., 2024). Te zdravstvene težave delavcev pa lahko vodijo k absentizmu in prezentizmu, kar na dolgi rok podjetjem prinaša nezaželene stroške ter povzroča nezadovoljstvo zaposlenih (Balantič et al., 2016).

Raziskave povezave med umetno inteligenco in delom že vključujejo več sorodnih pregledov, vendar imajo drugačne poudarke. Soulami et al. (2024) so s kombinacijo bibliometričnega in sistematičnega pregleda širše obravnavali vpliv uvajanja umetne inteligence na zaposlene in njihovo dobro počutje ter izpostavili povezave z avtonomijo pri delu, stresom, duševnim zdravjem in etičnimi vprašanji. Literatura o oblikovanju dela dodatno poudarja, da digitalne tehnologije lahko hkrati spreminjajo delovne zahteve in vire zaposlenih (Parker & Grote, 2022), medtem ko Parent-Rocheleau in Parker (2022) pri algoritmičnem upravljanju posebej opozarjata na spremembe v avtonomiji, kompleksnosti dela in delovni obremenitvi. Kljub temu je delovna obremenitev kot povezovalni pojem med raziskovanjem umetne inteligence, oblikovanjem dela ter zdravjem in dobrim počutjem zaposlenih bibliometrično manj jasno izpostavljena. Ta študija zato zapolnjuje ožje opredeljeno vrzel z bibliometričnim prikazom razvoja in strukture

raziskovanja delovnih obremenitev na presečišču tehnološke, zdravstvene in organizacijske literature v obdobju 2021–2025.

Raziskovalno vprašanje (RV) v tej študiji se zato glasi: kako se je med letoma 2021 in 2025 razvijalo raziskovanje na presečišču umetne inteligence, delovnih obremenitev in dobrega počutja ter kakšno bibliometrično strukturo področja kažejo publikacijski trendi, strokovna področja, institucije, ključne besede, mednarodno sodelovanje in sosclicevanje?

Namen prispevka je z bibliometrično analizo prikazati razvoj in strukturo raziskovanja na presečišču umetne inteligence, delovnih obremenitev in dobrega počutja v obdobju 2021–2025 ter opredeliti glavne disciplinarne, institucionalne in bibliometrične vzorce področja.

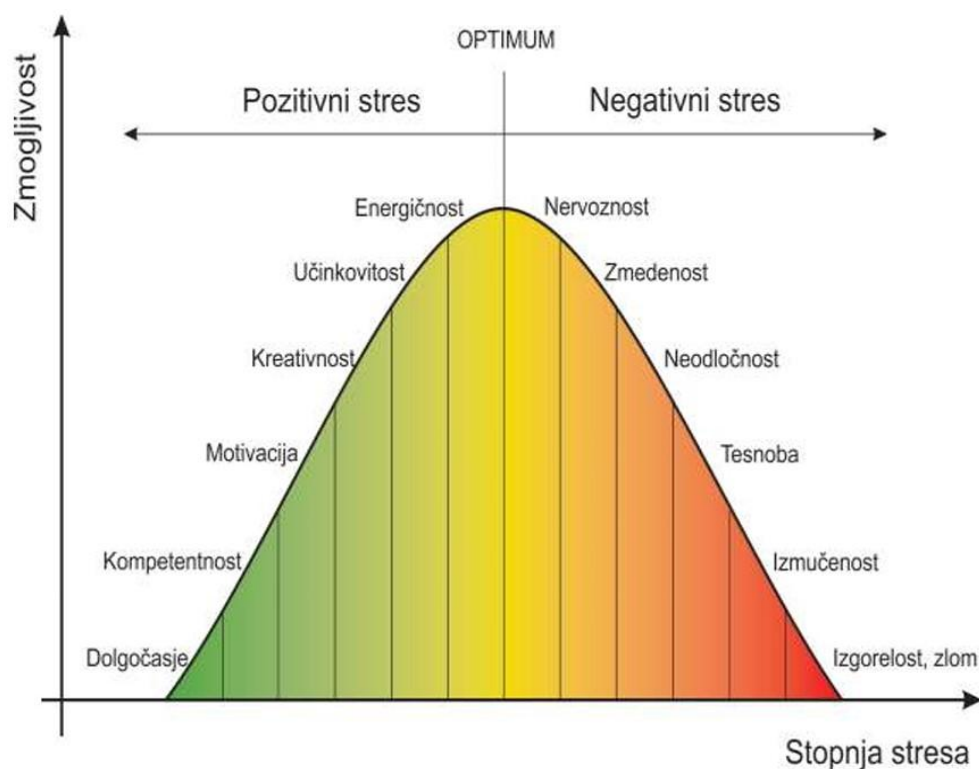
2 Teoretična izhodišča

Delovna obremenitev ni enodimenzionalni pojem. V ergonomiji pogosto ločujemo fizično, mentalno in časovno obremenitev, kar povezujemo z zahtevami, ki izhajajo iz dela (zahteve naloge, okolja, organizacije). Pomembno pa je tudi ločiti med obremenitvami in obremenjenostjo (odzivom posameznika) (Balantič et al., 2016). Standard ISO 10075-1 opredeli terminologijo mentalne obremenitve (duševni stres in duševni napor) ter posledice, ki so lahko kratkoročno pozitivne, dolgoročno pa tudi negativne (International Organization for Standardization, 2017). Tudi novejši pregledne razprave opozarjajo, da raziskovalci pogosto mešajo pojme in zato napačno razlagajo rezultate meritev mentalne obremenitve (Bartolomei et al., 2026).

Pri razlagi povezav med obremenitvijo, učinkovitostjo in dobrim počutjem delavcev je koristno ločiti med »optimalnim« območjem in območjem preobremenitve: kratkotrajna psihofiziološka aktivacija lahko poveča energičnost in zbranost, daljša ali pretirana obremenitev pa dvigne tveganje za konflikte, tesnobo, izčrpanost in izgorelost (International Organization for Standardization, 2017). To so leto prej podobno opredelili Balantič in sodelavci (2016), kar je razvidno na Sliki 1.

Slika 1

Prikaz optimalnega območja delovanja ter prehoda iz pozitivnega v negativni stres (Balantič et al., 2016)



Svetovna zdravstvena organizacija opredeli izgorelost kot pojav v poklicnem kontekstu, ki je posledica kroničnega stresa na delovnem mestu, s tremi ključnimi razsežnostmi (izčrpanost, odmik/cinizem, manjša delovna učinkovitost), in poudari, da to ni medicinska diagnoza (World Health Organization, 2019).

V organizacijskem delu literature je pogosta razlaga preko modela zahtev in virov dela (JD-R): zahteve (npr. časovni pritiski, kognitivna zahtevnost, čustvena obremenitev) povečujejo tveganje za izčrpanost, viri (npr. avtonomija, podpora, jasnost vlog, povratna informacija, usposabljanje) pa delujejo varovalno in krepijo angažiranost (Bakker & Demerouti, 2017). Ta okvir je uporaben za razumevanje, zakaj uvedba UI v nekaterih primerih zmanjša rutino in fizične obremenitve, v drugih pa poveča intenzivnost, zmanjša avtonomijo ali povzroči nov »nadzorni« tip dela (González Vázquez et al., 2024).

Za merjenje obremenitve raziskave uporabljajo subjektivne, vedenjske in fiziološke kazalnike. Najbolj razširjena subjektivna ocena mentalne obremenitve je NASA-TLX, ki združuje več komponent (npr. mentalni napor, časovni pritisk, frustracija) (Hart & Staveland, 1988). Druga izdaja standarda ISO 10075-2 dodatno usmerja načela oblikovanja dela in pogojev dela glede na mentalno obremenitev, kar je relevantno pri načrtovanju delovnih vlog z UI (npr. nadzor in odločanje) (International Organization for Standardization, 2024).

Pri upravljanju psihosocialnih tveganj v organizacijah je pomemben tudi standard ISO 45003, ki daje smernice za upravljanje psihosocialnih tveganj v sistemu vodenja varnosti in zdravja pri delu in izrecno usmerja v preprečevanje škode ter podporo dobrega počutja pri delu (International Organization for Standardization, 2021). Slovenske smernice za preprečevanje in obvladovanje psihosocialnih tveganj poudarjajo, da se vlaganje v preprečevanje obrestuje skozi manj odsotnosti, več zadovoljstva, motivacije in varnosti (Ministrstvo za delo, družino, socialne zadeve in enake možnosti, 2024).

Digitalizacija in posebej sistemi za algoritmično upravljanje dela lahko povečajo izpostavljenost dejavnikom, kot so višja intenzivnost dela, manj avtonomije, kognitivna preobremenitev, strah pred nadzorom in stres. V Sloveniji Nacionalni inštitut za javno zdravje posebej opozarja na psihosocialna tveganja, povezana z vodenjem delavcev z UI in algoritmi (Nacionalni inštitut za javno zdravje, 2025). S tem se razprava navezuje tudi na širše koncepte tehnostresa in digitalnega dela, kjer se obremenitve ne pojavljajo le zaradi zahtev naloge, temveč tudi zaradi stalne vključenosti v tehnološki proces, nadzora, hitrosti odzivanja in odvisnosti od digitalnih sistemov.

Empirične raziskave dodatno kažejo, da so učinki algoritmičnega upravljanja povezani z značilnostmi oblikovanja dela in dobrim počutjem zaposlenih. Kinowska in Sienkiewicz (2023) sta na velikem vzorcu evropskih organizacij ugotovili povezave med algoritmičnim upravljanjem, avtonomijo pri delu in dobrim počutjem zaposlenih. Wang et al. (2023) so v okviru modela delovnih zahtev in virov pokazali, da tehnostres vpliva na dobro počutje zaposlenih tudi prek delovne izčrpanosti. Raziskava Felix et al. (2023) med platformnimi delavci je dodatno pokazala, da je dobro počutje odvisno od razmerja med avtonomijo, varnostjo in zahtevami dela ter da lahko v določenih okoliščinah nastane tudi nevzdržna delovna obremenitev. Cram et al. (2022) pa so pri voznikih Uberja pokazali povezavo med algoritmičnim nadzorom in različnimi oblikami tehnostresa.

Iz navedenega izhaja, da vpliva UI na delovne obremenitve ni mogoče razumeti le kot tehnično vprašanje avtomatizacije nalog. Ključno je, kako se z uvedbo UI spremenijo zahteve dela, stopnja avtonomije, nadzor nad delom, časovni pritiski in odgovornost zaposlenih pri odločanju. UI lahko zmanjša nekatere rutinske ali fizične zahteve, hkrati pa lahko poveča mentalno obremenitev, potrebo po stalnem spremljanju sistema, obravnavo izjem, prilagajanje algoritemskim odločitvam in občutek nadzora. Zato je treba delovne obremenitve v okoljih, podprtih z UI, obravnavati kot rezultat razmerja med tehnološkim sistemom, organizacijo dela in izkušnjo zaposlenega. Takšno razumevanje povezuje ergonomski pogled na obremenitve z organizacijskim pogledom na zahteve in vire dela ter omogoča bolj kritično razlago vpliva UI na dobro počutje, stres in izgorelost.

Podobno opozarjajo tudi Molek et al. (2025), ki pri preučevanju uporabe generativne UI v visokošolskem okolju pokažejo, da sprejemanje UI ni odvisno le od tehničnih zmožnosti orodij, temveč tudi od institucionalnih praks, kulturnega okolja, digitalne pismenosti, etičnega

premisleka in regulativnih pričakovanj. Čeprav se njihova študija nanaša na visoko šolstvo, je ugotovitev pomembna tudi za delovna okolja, saj kaže, da ima uvedba UI vedno organizacijsko in družbeno razsežnost. Pri razlagi delovnih obremenitev je zato treba poleg učinkovitosti in avtomatizacije upoštevati tudi zaupanje, odgovornost, avtonomijo, nadzor, usposobljenost uporabnikov in pravila uporabe UI.

3 Metoda

Študija temelji na bibliometrični analizi znanstvene literature (Donthu et al., 2021; Zupic & Čater, 2015). Kot podatkovni vir smo uporabili bibliografsko zbirko Scopus (Elsevier, 2026). Iskanje je bilo izvedeno 21. aprila 2026. Analizirali smo publikacije iz obdobja 2021–2025. Končni bibliografski nabor je obsegal 399 dokumentov (N = 399). Obdobje smo izbrali tako, da zajema pet zaključenih koledarskih let in s tem omogoča pregled nedavnega razvoja raziskovanja na presečišču umetne inteligence, delovnih obremenitev in dobrega počutja pri delu.

Vključeni so bili zapisi, ki so bili objavljeni med letoma 2021 in 2025, v angleškem jeziku ter so bili v zbirki Scopus razvrščeni kot znanstveni članek (article), pregledni članek (review) ali konferenčni prispevek (conference paper). Iskanje je potekalo v naslovih, povzetkih in ključnih besedah. Uporabljen je bil naslednji iskalni niz:

TITLE-ABS-KEY (("artificial intelligence" OR AI) AND ("workload" OR "job demands" OR "work demands" OR "cognitive load") AND (wellbeing OR "mental health" OR stress OR burnout)) AND PUBYEAR > 2020 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re"))

Kriteriji izključevanja so bili določeni z iskalno strategijo in filtri zbirke Scopus. Izključeni so bili dokumenti zunaj obdobja 2021–2025, dokumenti v drugih jezikih ter vrste dokumentov, ki niso bile opredeljene kot article, review ali conference paper. Po izvozu iz zbirke Scopus nismo izvajali dodatnega čiščenja, deduplikacije ali vsebinskega izločanja zapisov. Prav tako nismo združevali rezultatov iz različnih bibliografskih zbirk, saj je raziskava temeljila izključno na zbirki Scopus. V bibliometrično analizo so bili zato vključeni vsi zapisi, ki so izpolnili navedeni iskalni niz in filtre. Bibliometrično analizo smo izvedli s programom VOSviewer, različica 1.6.20 (Van Eck & Waltman, 2023). Pri izdelavi bibliometričnih mrež smo uporabili način full counting. Za normalizacijo moči povezav je bila uporabljena metoda association strength. Normalizacija omogoča primerjavo relativne moči povezav med elementi mreže in zmanjšuje vpliv razlik v njihovi absolutni pogostosti. Metoda »association strength« je privzeta metoda normalizacije v VOSviewerju 1.6.20.

Analiza je obsegala šest sklopov: rast števila publikacij po letih, porazdelitev publikacij po strokovnih področjih, porazdelitev po raziskovalnih institucijah, analizo sočasnega pojavljanja ključnih besed, analizo soavtorstva med državami in analizo sosclicovanja citiranih avtorjev.

Rast publikacij smo ugotavljali s številom dokumentov po posameznem letu objave. Pri strokovnih področjih smo prikazali področja z najmanj desetimi dokumenti. Pri raziskovalnih institucijah smo prikazali institucije z najmanj štirimi dokumenti. Podatki za prikaz rasti publikacij, porazdelitve po strokovnih področjih in raziskovalnih institucijah so bili pridobljeni neposredno iz rezultatov in analitičnih prikazov zbirke Scopus. Na tej podlagi so bile pripravljene Slika 2, Slika 3 in Tabela 1.

Pri analizi sočasnega pojavljanja ključnih besed (co-occurrence) je bila kot enota analize uporabljena možnost »all keywords«, ki vključuje vse ključne besede v bibliografskih zapisih. Uporabljen je bil način »full counting«. V mrežo so bile vključene ključne besede z najmanj petimi pojavitvami. Tezavrska datoteka ni bila uporabljena, zato sinonimi in terminološke različice pred izdelavo mreže niso bili ročno združeni. To dejstvo smo upoštevali pri interpretaciji rezultatov.

Pri analizi soavtorstva med državami (co-authorship – countries) je bil uporabljen način »full counting«. Država je morala imeti najmanj pet dokumentov; dodatni minimalni prag citatov je bil nastavljen na 0. V vhodnih podatkih je bilo zaznanih 71 držav, od katerih jih je 22 doseglo določeni prag. Pri analizi soavtorstva med državami smo uporabili nastavitve, ki iz analize izključijo dokumente z več kot 25 državami soavtoricami, da posamezne publikacije z zelo velikim številom sodelujočih držav ne bi nesorazmerno vplivale na strukturo mreže.

Pri analizi sosklicevanja (co-citation) so bili enota analize citirani avtorji (cited authors). Uporabljen je bil način »full counting«, prag vključitve pa najmanj deset citatov posameznega citiranega avtorja. Imena citiranih avtorjev so bila uporabljena v obliki, kot so bila zajeta v bibliografskih podatkih; dodatno ročno razreševanje avtorjev z enakim priimkom in začetnico ni bilo izvedeno. Zato smo rezultate sosklicevanja interpretirali kot vzorce skupnega citiranja oznak avtorjev in ne kot dokaz enake raziskovalne usmeritve posameznih avtorjev.

Grozde v bibliometričnih mrežah je oblikoval algoritem VOSviewer na podlagi strukture povezav med elementi. Grozdi zato niso bili določeni vnaprej glede na teoretične kategorije. Barve v mrežah označujejo programsko določene skupine povezanih elementov. Vsebinsko poimenovanje in razlaga grozdov predstavljata avtorsko interpretacijo najpogostejših in najizraziteje povezanih elementov znotraj posamezne skupine. Pri grozdenju smo ohranili privzete nastavitve programa VOSviewer 1.6.20 in parametrov grozdenja nismo ročno spreminjali.

Podatki in analitična gradiva, vključno z izpeljanimi podatki za tabele, slike in bibliometrične analize, so na razumno zahtevo dostopni pri avtorjih. Dostop do izvornih bibliografskih zapisov iz zbirke Scopus je omejen z licenčnimi pogoji zbirke.

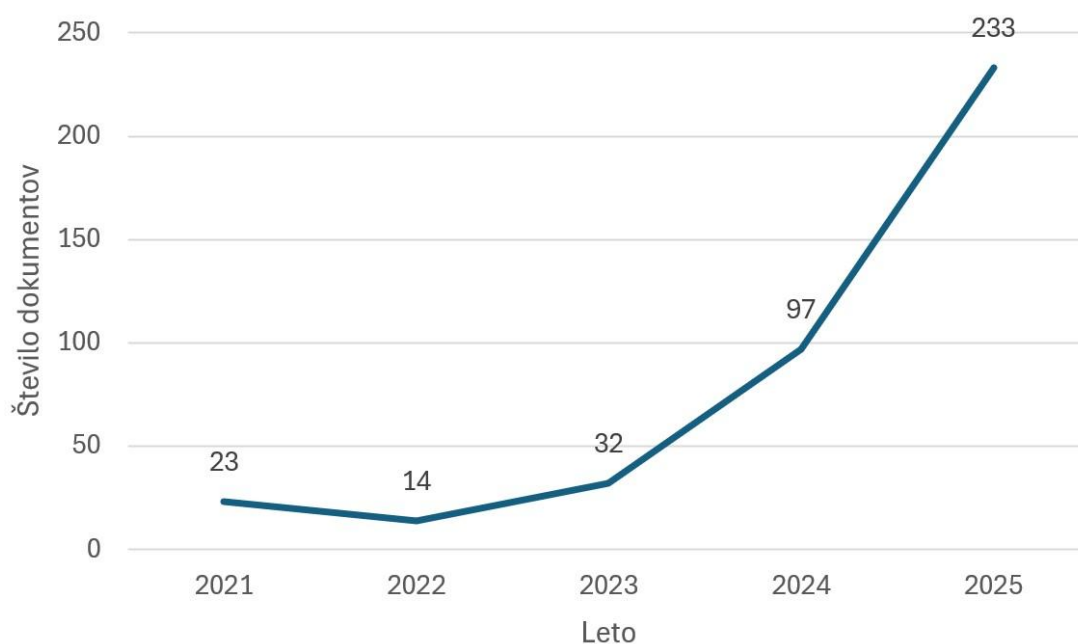
4 Rezultati

4.1 Rast publikacij po letih

Slika 2 prikazuje, da se je število dokumentov z 23 leta 2021 zmanjšalo na 14 leta 2022, nato pa naraslo na 32 leta 2023, 97 leta 2024 in 233 leta 2025. Leta 2025 je tako nastalo 58,4 % celotnega analiziranega nabora (233/399), število dokumentov pa je bilo približno desetkrat večje kot leta 2021. Podatki zato kažejo izrazito rast predvsem v letih 2024–2025, ne pa neprekinjene rasti skozi celotno obdobje.

Slika 2

Rast objav po letih (lastna analiza podatkov Scopus; iskanje izvedeno 21. aprila 2026)



4.2 Porazdelitev po strokovnih področjih

Porazdelitev na Tabeli 1 po strokovnih področjih kaže izrazito zastopanost računalništva, medicine in inženirstva. Računalništvo zajema 181 dokumentov (45,4 %), medicina 144 (36,1 %), inženirstvo pa 117 dokumentov (29,3 %). Med bolj zastopanimi področji so tudi družboslovje s 63 dokumenti (15,8 %) ter matematika s 36 dokumenti (9,0 %). Predstavljena so strokovna področja z najmanj desetimi dokumenti. Posamezen dokument je lahko v zbirki Scopus uvrščen v več strokovnih področjih, zato se deleži med seboj prekrivajo in njihov seštevek presega 100 %. Porazdelitev kaže, da raziskovanje na presečišču umetne inteligence, delovnih obremenitev in dobrega počutja vključuje več različnih disciplin.

Tabela 1

Glavna strokovna področja (lastna analiza podatkov Scopus; iskanje izvedeno 21. aprila 2026)

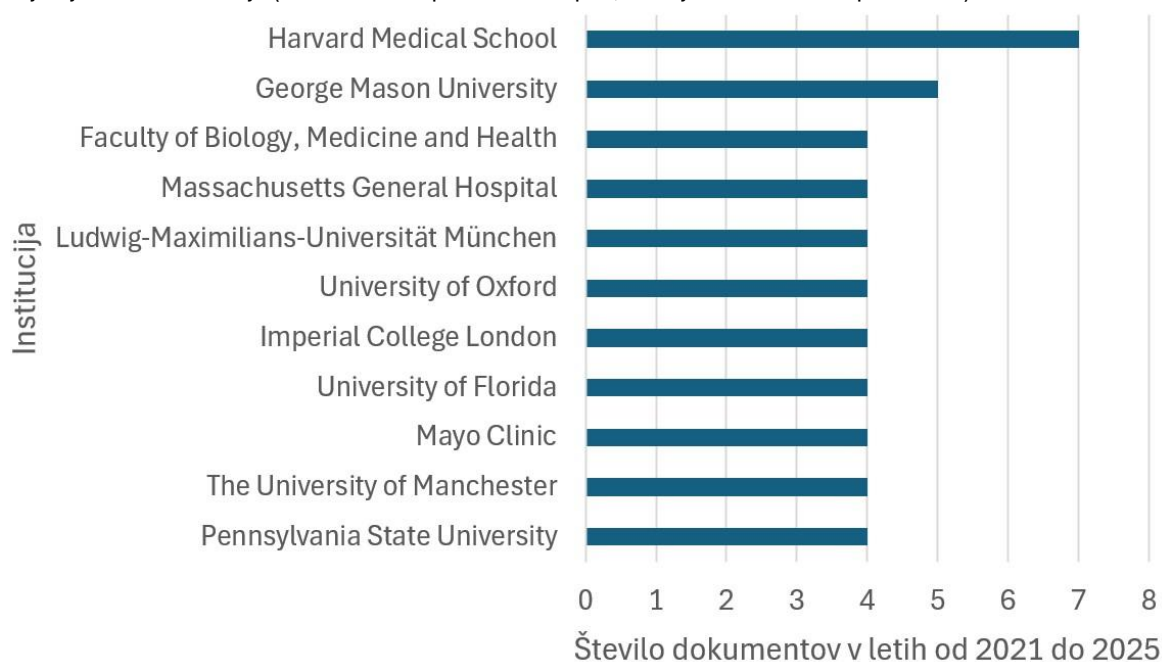
Strokovno področje	Število dokumentov
Computer Science	181
Medicine	144
Engineering	117
Social Sciences	63
Mathematics	36
Business, Management and Accounting	26
Nursing	23
Decision Sciences	23
Health Professions	21
Psychology	20
Physics and Astronomy	17
Energy	17
Neuroscience	11
Arts and Humanities	11
Materials Science	10

4.3 Porazdelitev po raziskovalnih institucijah

Med institucijami z najmanj štirimi dokumenti ima največ objav Harvard Medical School (7), sledi George Mason University (5), več drugih prikazanih institucij pa ima po štiri dokumente. Glede na končni nabor 399 dokumentov rezultati ne kažejo izrazite prevlade ene institucije, temveč razmeroma razpršeno institucionalno produkcijo med več univerzami ter kliničnimi in raziskovalnimi ustanovami, kar je razvidno iz Slike 3.

Slika 3

Najbolj aktivne institucije (lastna analiza podatkov Scopus; iskanje izvedeno 21. aprila 2026)

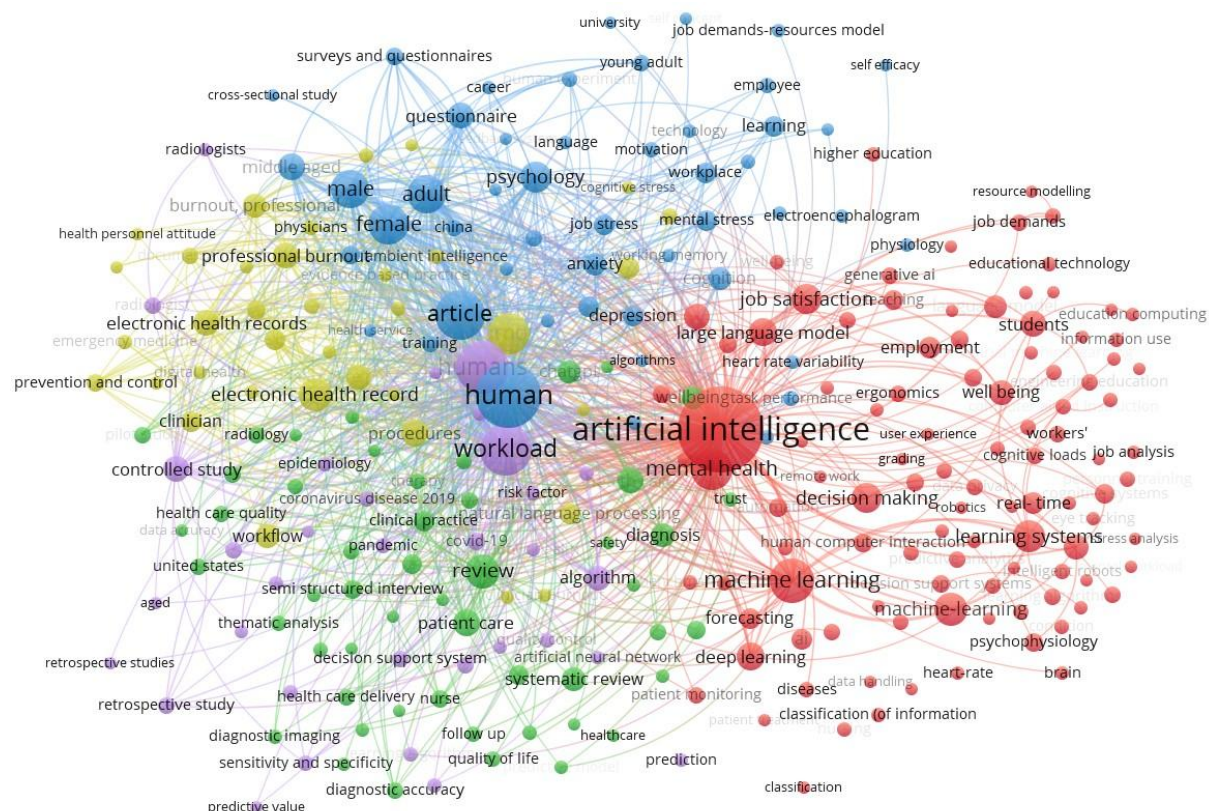


4.4 Sklopi ključnih besed

Analiza sočasnega pojavljanja vseh ključnih besed (Slika 4) je bila izvedena z orodjem VOSviewer. V mrežo so bili vključeni izrazi z najmanj petimi pojavitvami. Prag je doseglo 274 ključnih besed. Mreža je obsegala 11.216 povezav s skupno močjo povezav 26.002 ter se razdelila v pet grozdov. Velikost vozlišča odraža pogostost pojavljanja posameznega izraza, povezave med vozlišči pa njihovo sočasno pojavljanje v analiziranih dokumentih. Barve označujejo grozde, ki jih je na podlagi strukture povezav določil algoritem VOSviewer.

Slika 4

Mreža ključnih besed



Analiza je pokazala pet medsebojno povezanih grozdov, katerih vsebinske značilnosti so povzete v Tabeli 2. Največji, rdeči grozd povezuje umetno inteligenco in strojno učenje s kognitivno oziroma mentalno obremenitvijo, človeškimi dejavniki, zahtevami dela, stresom in dobrim počutjem. Zelen grozd je izraziteje usmerjen v zdravstveno obravnavo, klinično odločanje, varnost pacientov, kakovost obravnave in zaupanje. Moder grozd združuje poklicni in mentalni stres, psihološko dobro počutje, model delovnih zahtev in virov ter psihofiziološke kazalnike. Rumen grozd povezuje izgorelost zdravstvenih delavcev z digitalnim zdravstvom, elektronsko zdravstveno dokumentacijo in generativno UI. Vijoličen grozd pa združuje algoritmične in napovedne pristope, diagnostično učinkovitost ter izraze, povezane z intenzivno medicino, radiologijo in delovno obremenitvijo. Ker grozde določi VOSviewer na podlagi strukture povezav, njihove vsebinske oznake predstavljajo avtorsko interpretacijo in ne vnaprej določenih kategorij.

Tabela 2

Značilnosti grozdov ključnih besed v mreži sočasnega pojavljanja

Grozd	Število elementov	Vsebinska interpretacija	Primeri značilnih izrazov
Rdeč	105	Umetna inteligenca, kognitivna obremenitev in človeški dejavniki pri delu	artificial intelligence, machine learning, generative AI, cognitive load, cognitive workloads, mental workload, job demands, human factors, job satisfaction, stress, well-being, work-life balance
Zelen	51	Klinično odločanje, kakovost zdravstvene obravnave in zaupanje	clinical decision making, clinical decision support systems, patient care, patient safety, patient satisfaction, health care quality, personalized medicine, trust, privacy, workforce
Moder	49	Poklicni stres, psihološko dobro počutje in psihofiziološki odzivi	occupational stress, job stress, mental stress, anxiety, depression, job demands-resources model, psychological well-being, heart rate variability, electroencephalography, self-efficacy, questionnaire
Rumen	36	Izgorelost zdravstvenih delavcev, digitalno zdravstvo in generativna UI	burnout, professional burnout, clinician burnout, digital health, electronic health record, electronic health records, generative artificial intelligence, natural language processing, physicians, medical education, workflow algorithm, artificial neural network, diagnostic test accuracy, intensive care unit, radiologists, predictive value, receiver operating characteristic, telemedicine, fatigue, workload, COVID-19
Vijoličen	33	Klinični modeli, diagnostična učinkovitost in delovna obremenitev	

4.5 Sodelovanje med državami

Analiza soavtorstva med državami je pokazala, da je bilo v vhodnih podatkih zaznanih 71 držav, od katerih jih je 22 doseglo prag najmanj petih dokumentov in bilo vključenih v mrežo. Mreža, vidna na Sliki 5, je obsegala 74 sodelovalnih povezav s skupno močjo povezav 104 ter se razdelila v šest grozdov. Število dokumentov, število povezav in skupna moč povezav za deset držav z največjim številom dokumentov so prikazani v Tabeli 3. Prvi grozd sestavljajo Nemčija, Grčija, Italija, Nizozemska, Švica in Tajvan; drugi Kanada, Izrael, Japonska, Španija in Združene države Amerike; tretji Avstralija, Indija, Savdska Arabija in Združeno kraljestvo; četrti Kitajska, Južna Koreja in Turčija; peti Indonezija in Malezija; šesti pa Poljska in Švedska. Povezave med državami predstavljajo soavtorsko sodelovanje v analiziranem naboru, grozdi pa skupine držav z gostejšimi vzorci medsebojnih povezav. Razporeditev tako kaže, da je mednarodno sodelovanje prisotno v več medsebojno povezanih skupinah, pri čemer bibliometrična mreža prikazuje strukturo sodelovanja in ne njegove kakovosti ali vsebinske podobnosti raziskav.

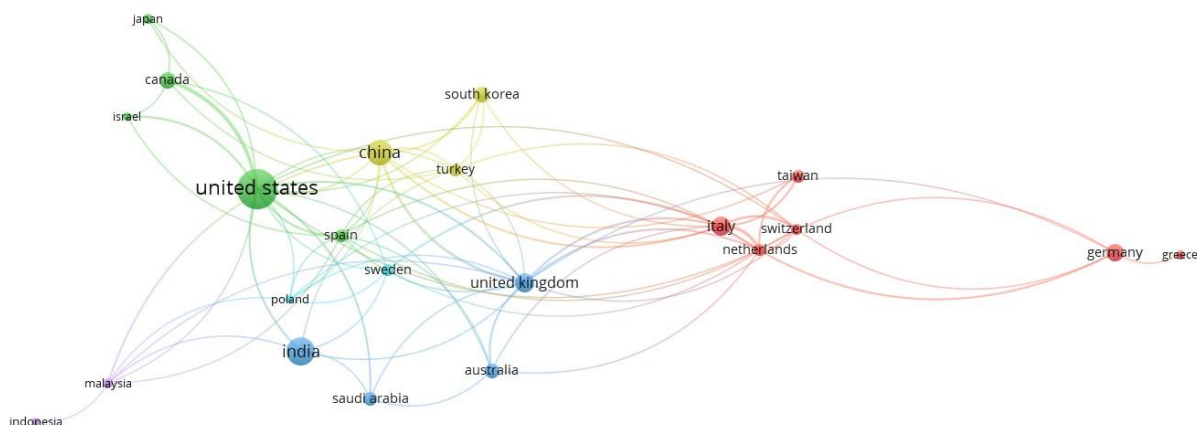
Tabela 3

Glavne države glede na število dokumentov in kazalnike mednarodnega sodelovanja

Država	Dokumenti	Povezave	Skupna moč povezav
Združene države Amerike	102	16	27
Indija	59	6	7
Kitajska	43	10	16
Italija	24	11	22
Združeno kraljestvo	23	14	21
Nemčija	21	5	6
Kanada	20	5	11
Južna Koreja	16	5	6
Savdska Arabija	12	4	5
Avstralija	12	6	7

Slika 5

Meddržavno sodelovanje



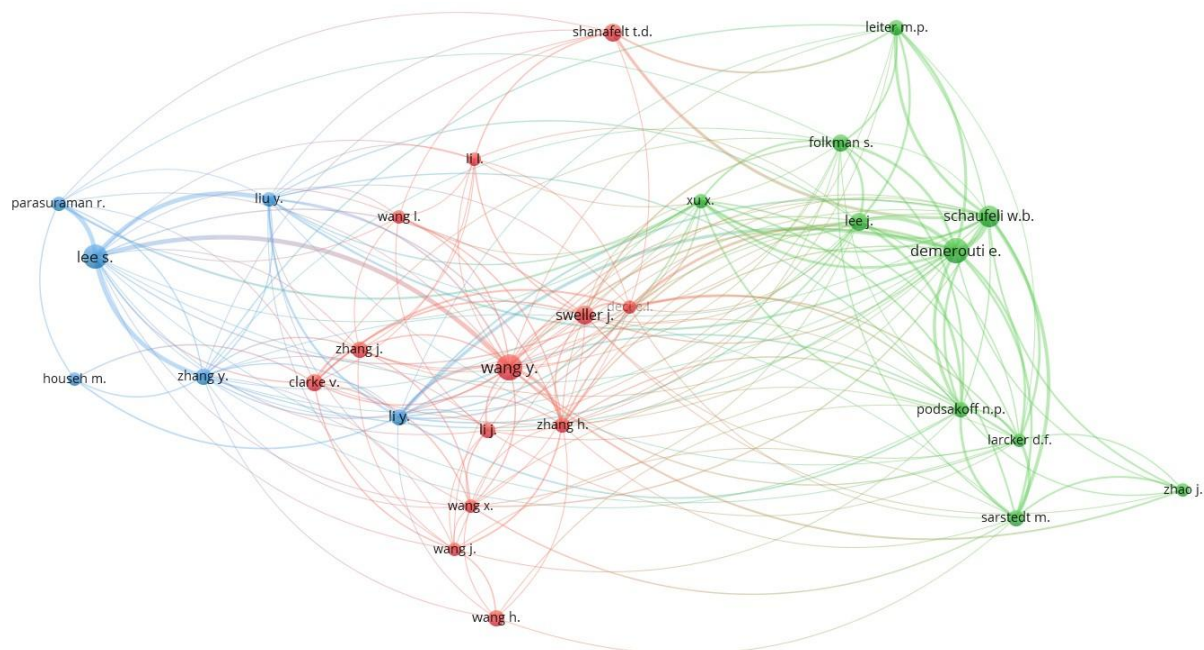
4.6 Sopovezanost avtorjev

Analiza sopovezanosti citiranih avtorjev je pokazala, da je prag najmanj desetih citatov doseglo 29 oznak citiranih avtorjev. Mreža, vidna na Sliki 6, je obsegala 207 povezav s skupno močjo povezav 638 ter se razdelila v tri grozde. Velikost vozlišča odraža pogostost citiranja posamezne oznake avtorja, povezave pa kažejo, kako pogosto so posamezni avtorji citirani skupaj v dokumentih analiziranega nabora. Barve označujejo grozde, ki jih je na podlagi strukture povezav določil algoritem VOSviewer.

Med izrazitejšimi oznakami citiranih avtorjev v mreži so Wang Y., Li J. in Zhang H. Njihova bližina in povezave pomenijo, da jih dokumenti v analiziranem naboru pogosteje navajajo skupaj. Med drugimi vidnejšimi oznakami so Demerouti E., Schaufeli W. B. in Leiter M. P. ter Lee S. in Liu Y. Iz same mreže sopovezanosti ni mogoče sklepati, da imajo citirani avtorji enako raziskovalno usmeritev ali da predstavljajo enotno vsebinsko raziskovalno smer; za takšno presojo bi bil potreben vsebinski pregled njihovih del. Pri interpretaciji je treba upoštevati tudi, da dodatno ročno razreševanje morebitno dvoumnih imen avtorjev ni bilo izvedeno.

Slika 6

Sopovezanost avtorjev

**5 Razprava**

Rezultati kažejo izrazito rast raziskovalnega zanimanja, zlasti v letih 2024 in 2025, ter multidisciplinarno strukturo področja. Te ugotovitve je mogoče umestiti v širši kontekst evropskih raziskav digitalizacije dela, ki opozarjajo, da lahko avtomatizacijo spremljajo tako zmanjšanje nekaterih fizičnih obremenitev kot povečanje intenzivnosti dela, časovnega pritiska, težav pri razmejevanju delovnega in zasebnega časa ter nadzora (González Vázquez et al., 2024). Sorodne empirične raziskave kažejo, da je algoritmično upravljanje povezano s spremembami avtonomije, tehnostresom in dobrim počutjem zaposlenih ter da se učinki razlikujejo glede na način uporabe tehnologije in značilnosti dela (Kinowska & Sienkiewicz, 2023; Cram et al., 2022; Felix et al., 2023). Na podobna psihosocialna tveganja pri algoritmičnem upravljanju opozarjajo tudi evropske smernice in poročila (European Agency for Safety and Health at Work, 2025).

Rezultati prav tako kažejo, da je raziskovanje na presečišču umetne inteligence, delovnih obremenitev in dobrega počutja izrazito multidisciplinarno. Analiza ključnih besed pokaže, da področje ni vsebinsko enotno, temveč se oblikuje v več medsebojno povezanih sklopih. Največji grozd povezuje umetno inteligenco in strojno učenje s kognitivno in mentalno obremenitvijo, človeškimi dejavniki, zahtevami dela, stresom in dobrim počutjem. Drugi in peti grozd sta izraziteje povezana s kliničnim odločanjem, kakovostjo zdravstvene obravnave, diagnostičnimi pristopi in delovno obremenitvijo, medtem ko tretji grozd povezuje poklicni stres, psihološko dobro počutje, model delovnih zahtev in virov ter psihofiziološke kazalnike. Četrti grozd izpostavlja povezavo med izgorelostjo zdravstvenih delavcev, digitalnim zdravstvom in

generativno umetno inteligenco. Takšna struktura potrjuje, da se vprašanje delovnih obremenitev ob UI preučuje na presečišču tehnoloških, zdravstvenih in psihosocialnih tem.

V primerjavi s sorodnimi pregledi se ta študija osredotoča na nekoliko ožje opredeljeno presečišče raziskovanja. Soulami et al. (2024) so s kombinacijo bibliometričnega in sistematičnega pregleda širše obravnavali vpliv uvajanja umetne inteligence na zaposlene in njihovo dobro počutje ter izpostavili povezave z avtonomijo pri delu, stresom, duševnim zdravjem in etičnimi vprašanji. Sorodna literatura o oblikovanju dela poudarja, da učinkov digitalnih tehnologij ni mogoče razumeti zgolj z vidika njihove tehnološke funkcionalnosti, saj lahko njihova uvedba hkrati spreminja zahteve dela in vire, ki so zaposlenim na voljo (Parker & Grote, 2022). Podobno Parent-Rochelleau in Parker (2022) pri algoritmičnem upravljanju pokažeta, da lahko avtomatizacija managerskih funkcij posega v značilnosti dela, kot so avtonomija, kompleksnost dela in delovna obremenitev. Sedanja raziskava se na to literaturo navezuje z ožjim bibliometričnim poudarkom na delovni obremenitvi kot povezovalnem pojmu med umetno inteligenco, oblikovanjem dela ter zdravjem in dobrim počutjem zaposlenih. Izvirnost prispevka zato ni v prvem splošnem pregledu vplivov umetne inteligence na zaposlene, temveč v sistematičnem bibliometričnem prikazu, kako se raziskovanje delovnih obremenitev v obdobju 2021–2025 umešča med tehnološko, zdravstveno in organizacijsko literaturo.

Naša bibliometrična analiza sama ne omogoča ocene, kako pogosto študije uporabljajo validirane mere dobrega počutja ali longitudinalne in intervencijske zasnove. Na potrebo po več metodološko raznolikih, longitudinalnih in kontekstualno širših raziskavah pa opozarjajo sorodni sistematični pregledi raziskav umetne inteligence in dobrega počutja zaposlenih (Soulami et al., 2024). Te ugotovitve zato razumemo kot širši kontekst za interpretacijo našega bibliometričnega zemljevida in ne kot neposreden rezultat analiziranega nabora.

Model delovnih zahtev in virov (JD-R) je bil v tej študiji uporabljen kot interpretativni okvir po izvedeni bibliometrični analizi. Bibliometrični grozdi niso bili določeni na podlagi kategorij JD-R, temveč jih je oblikoval algoritem VOSviewer na podlagi strukture povezav med izrazi. Po izdelavi mrež smo rezultate interpretirali glede na pojme, povezane z zahtevami dela, viri dela ter zdravstvenimi in motivacijskimi izidi. Pri tem se izraz »job demands-resources model« pojavlja v tretjem grozdu skupaj z izrazi, povezanimi s poklicnim in mentalnim stresom ter psihološkim dobrim počutjem. To kaže na prisotnost konceptov, ki so vsebinsko skladni z modelom JD-R, ne pomeni pa, da je ta model usmerjal oblikovanje bibliometričnih grozdov. V tem smislu lahko pojme, kot so delovna obremenitev, stres in izgorelost, razumemo v povezavi z zahtevami dela in njihovimi posledicami, medtem ko JD-R opozarja tudi na pomen virov dela, kot so avtonomija, podpora in povratne informacije. Takšna razlaga je skladna tudi z empiričnimi raziskavami tehnostresa, ki v okviru modela JD-R kažejo, da lahko tehnološke zahteve prek izčrpanosti zmanjšujejo dobro počutje zaposlenih (Wang et al., 2023).

Regulativni okvir dodatno poudarja pomen uporabe UI na področju zaposlovanja in upravljanja dela. Uredba (EU) 2024/1689 med visoko tvegane uvršča določene sisteme UI, namenjene zaposlovanju in izbiri kandidatov ter odločanju o delovnih razmerjih, razporejanju nalog ter spremljanju in ocenjevanju uspešnosti oziroma vedenja zaposlenih (Uredba (EU) 2024/1689).

Z vidika prakse bibliometrični rezultati kažejo, da se vprašanje umetne inteligence in delovnih obremenitev umešča v širše presečišče tehnoloških, zdravstvenih in organizacijskih vprašanj. Zato učinkov uvajanja UI ni smiselno presojati zgolj z vidika učinkovitosti ali produktivnosti, temveč tudi z vidika značilnosti dela in dobrega počutja zaposlenih. Literatura o oblikovanju dela poudarja, da lahko digitalne tehnologije hkrati spreminjajo zahteve dela in vire, ki so zaposlenim na voljo, zato so pri uvajanju UI pomembni spremljanje delovnih obremenitev, ohranjanje ustrezne avtonomije, kakovost povratnih informacij ter vključevanje zaposlenih v procese uvajanja in evalvacije novih sistemov (Parker & Grote, 2022; Parent-Rochelleau & Parker, 2022). Takšno razumevanje je skladno tudi s širšimi priporočili glede upravljanja psihosocialnih tveganj pri delu, ki poudarjajo sistematično prepoznavanje, spremljanje in obvladovanje dejavnikov, povezanih z organizacijo in oblikovanjem dela (International Organization for Standardization, 2021).

Bibliometrična analiza sama ne omogoča ocene deleža longitudinalnih, intervencijskih ali drugih raziskovalnih zasnov v analiziranem naboru, zato iz naših rezultatov ni mogoče sklepati, da posamezne metodološke zasnove prevladujejo ali so redke. Sorodni sistematični pregledi pa opozarjajo na potrebo po metodološko raznolikih in longitudinalnih raziskavah, ki bi omogočile natančnejše spremljanje sprememb v delovnih obremenitvah in dobrem počutju zaposlenih skozi čas (Soulami et al., 2024). Prihodnje raziskave bi zato lahko bibliometrično kartiranje dopolnile z vsebinskimi sistematičnimi pregledi ter longitudinalnimi in intervencijskimi študijami.

Pomembna smer nadaljnjega raziskovanja je tudi vprašanje, kako različne oblike uporabe umetne inteligence spreminjajo značilnosti dela. Literatura o oblikovanju dela in algoritmičnem upravljanju kaže, da lahko digitalne tehnologije vplivajo tako na delovne zahteve kot na vire zaposlenih, vključno z delovno obremenitvijo, avtonomijo, kompleksnostjo dela in povratnimi informacijami (Parker & Grote, 2022; Parent-Rochelleau & Parker, 2022). Prihodnje empirične raziskave bi lahko zato natančneje primerjale različne načine uvajanja UI, organizacijske kontekste in skupine zaposlenih ter preučile pogoje, v katerih tehnologija zahteve dela povečuje, zmanjšuje ali preoblikuje.

Bibliometrični rezultati te študije prav tako ne omogočajo kvantifikacije učinkovitosti organizacijskih, ergonomskih ali psihosocialnih ukrepov. Zato ostaja pomembno empirično vprašanje, kateri načini oblikovanja dela in organizacijske podpore lahko ob uvajanju UI prispevajo k uravnoteženju delovnih zahtev in virov. Kombinacija kvantitativnih, kvalitativnih in intervencijskih pristopov bi lahko omogočila natančnejše razumevanje povezav med tehnologijo, organizacijo dela in izkušnjami zaposlenih.

5.1 Omejitve raziskave

Raziskava ima več omejitev, ki jih je treba upoštevati pri interpretaciji rezultatov. Analiza temelji izključno na bibliografski zbirki Scopus, zato ne zajema nujno vseh relevantnih publikacij, indeksiranih v drugih bibliografskih zbirkah ali strokovnih virih. Vključene so bile samo publikacije v angleškem jeziku ter dokumenti, razvrščeni kot znanstveni članki, pregledni članki in konferenčni prispevki, kar lahko vpliva na geografsko in vsebinsko sestavo analiziranega nabora. Časovna omejitev na obdobje 2021–2025 omogoča vpogled v nedavni razvoj področja, ne pa v njegovo dolgoročno evolucijo. Rezultati so odvisni tudi od uporabljenega iskalnega niza; relevantne raziskave, ki uporabljajo drugačne izraze za umetno inteligenco, delovno obremenitev ali dobro počutje, zato morda niso bile zajete. Posebno omejitev predstavlja uporaba kratice »AI«, saj ima lahko tudi pomene, ki niso povezani z umetno inteligenco; dodatno vsebinsko izločanje zapisov glede na pomen kratice po izvozu ni bilo izvedeno.

Pri analizi sočasnega pojavljanja so bile uporabljene vse ključne besede, tezavska datoteka pa ni bila uporabljena. Posledično lahko mreža vsebuje sinonime, terminološke razlike in generične indeksne izraze kot ločene enote, kar omejuje vsebinsko interpretacijo posameznih grozdov. Podobno pri sopovezanosti citiranih avtorjev ni bilo izvedeno dodatno ročno razreševanje morebitno dvoumnih imen, zato je treba rezultate razumeti kot vzorce skupnega citiranja oznak avtorjev. Izbrani minimalni pragovi izboljšujejo preglednost bibliometričnih mrež, vendar hkrati izključujejo redkeje zastopane ključne besede, države in citirane avtorje. Nazadnje bibliometrične povezave prikazujejo strukturo, sopovezanost, sodelovanje in vzorce citiranja v literaturi, ne omogočajo pa vzročnega sklepanja o učinkih umetne inteligence na delovne obremenitve ali dobro počutje zaposlenih.

6 Zaključek

Bibliometrična analiza 399 dokumentov, objavljenih med letoma 2021 in 2025, kaže izrazito povečanje raziskovalnega zanimanja za presečišče umetne inteligence, delovnih obremenitev in dobrega počutja, zlasti v letih 2024 in 2025. Področje je izrazito interdisciplinarno, saj so med najbolj zastopanimi računalništvo, medicina in inženirstvo, institucionalna produkcija pa je razpršena med več univerzami ter kliničnimi in raziskovalnimi ustanovami.

Analiza ključnih besed kaže pet medsebojno povezanih grozdov, ki povezujejo umetno inteligenco in strojno učenje z mentalno in kognitivno obremenitvijo ter človeškimi dejavniki, kliničnim odločanjem in zdravstveno obravnavo, poklicnim stresom in psihološkim dobrim počutjem, izgorelostjo v zdravstvu ter diagnostičnimi in napovednimi pristopi. Mednarodno sodelovanje je organizirano v več skupin medsebojno povezanih držav, mreža sopovezanosti pa dodatno prikazuje strukturo skupnega citiranja citiranih avtorjev.

Model delovnih zahtev in virov (JD-R) omogoča interpretacijo teh bibliometričnih vzorcev z vidika ravnotežja med zahtevami dela, razpoložljivimi viri ter zdravstvenimi in motivacijskimi izidi.

Vendar bibliometrična analiza sama ne omogoča vzročnega sklepanja o tem, ali umetna inteligenca delovne obremenitve povečuje, zmanjšuje ali preoblikuje. Takšne učinke je treba preverjati z empiričnimi raziskavami v konkretnih delovnih okoljih. Nadaljnje raziskave lahko bibliometrično kartiranje dopolnijo z vsebinskimi, longitudinalnimi, kvalitativnimi in intervencijskimi pristopi ter tako natančneje pojasnijo, kako različni načini uvajanja umetne inteligence vplivajo na značilnosti dela in dobro počutje zaposlenih.

Reference

1. Bakker, A. B., & Demerouti, E. (2017). Job demands-resources theory: Taking stock and looking forward. *Journal of occupational health psychology*, 22(3), 273–285. <https://doi.org/10.1037/ocp0000056>
2. Balantič, Z., Polajnar, A., & Jevšnik, S. (2016). Ergonomija v teoriji in praksi. *Ljubljana: Nacionalni inštitut za javno zdravje*, 357-83.
3. Bartolomei, M., Gervasi, R., Acconito, C., Angioletti, L., Cannizzaro, D., Balconi, M., ... & Franceschini, F. (2026). Evaluating mental workload: A taxonomic approach to evaluation tools based on ISO 10075. *Applied Ergonomics*, 130, 104659. <https://doi.org/10.1016/j.apergo.2025.104659>
4. Breque, M., De Nul, L., & Petridis, A. (2021). *Industry 5.0: towards a sustainable, human-centric and resilient European industry* (No. KI-BD-20-021-EN-N). Directorate General for Research and Innovation (DG RTD) of the European Commission. <https://doi.org/10.2777/308407>
5. Cram, W. A., Wiener, M., Tarafdar, M., & Benlian, A. (2022). Examining the impact of algorithmic control on Uber drivers' technostress. *Journal of Management Information Systems*, 39(2), 426–453. <https://doi.org/10.1080/07421222.2022.2063556>
6. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*, 133, 285-296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
7. Elsevier. (2026). Scopus database. <https://www.scopus.com>
8. European Agency for Safety and Health at Work. (2025). *AI-driven and algorithmic worker management in EU workplaces: Discover the facts and figures*. <https://healthy-workplaces.osha.europa.eu/en/media-centre/news/ai-driven-and-algorithmic-worker-management-eu-workplaces-discover-facts-and-figures>
9. Felix, B., Dourado, D., & Nossa, V. (2023). Algorithmic management, preferences for autonomy/security and gig-workers' wellbeing: A matter of fit? *Frontiers in Psychology*, 14, 1088183. <https://doi.org/10.3389/fpsyg.2023.1088183>
10. González Vázquez, I., Curtarelli, M., Anyfantis, I., Brun, E., & Starren, A. (2024). Digitalisation and workers wellbeing: The impact of digital technologies on work-related psychosocial risks. JRC Working Papers Series on Labour, Education and Technology, 2024/03. European Commission, Joint Research Centre.
11. Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In *Advances in psychology* (Vol. 52, pp. 139-183). North-holland. [https://doi.org/10.1016/S0166-4115\(08\)62386-9](https://doi.org/10.1016/S0166-4115(08)62386-9)

12. International Organization for Standardization. (2017). *ISO 10075-1:2017: Ergonomic principles related to mental workload — Part 1: General issues and concepts, terms and definitions*. <https://www.iso.org/standard/66900.html>
13. International Organization for Standardization. (2021). *ISO 45003:2021: Occupational health and safety management — Psychological health and safety at work — Guidelines for managing psychosocial risks*. <https://www.iso.org/standard/64283.html>
14. International Organization for Standardization. (2024). *ISO 10075-2:2024: Ergonomic principles related to mental workload — Part 2: Design principles*. <https://www.iso.org/standard/76686.html>
15. Kinowska, H., & Sienkiewicz, Ł. J. (2023). Influence of algorithmic management practices on workplace well-being – Evidence from European organisations. *Information Technology & People*, 36(8), 21–42. <https://doi.org/10.1108/ITP-02-2022-0079>
16. Ministrstvo za delo, družino, socialne zadeve in enake možnosti. (2024). *Psihosocialna tveganja za varnost in zdravje pri delu: Smernice za njihovo učinkovito preprečevanje in obvladovanje*. Ljubljana: MDDSZ. https://zssszaupnikvzd.si/wp-content/uploads/2024/10/MDDSZ-smernice-2024-psihosocialna_tveganja_za_varnost_in_zdravje_pri_delu_splet.pdf
17. Molek, N., Imamović Lerić, L., Gorenc Zoran, A., & Ljevo, N. (2025). *Exploring the adoption of generative AI in higher education: A cross-national comparison*. In 16th International Conference on Information Technologies and Information Society: ITIS 2025: Conference proceedings, November 12–13, 2025, Otočec, Slovenia (pp. 187–200).
18. Nacionalni inštitut za javno zdravje. (2025). *Vpliv vodenja zaposlenih z UI in algoritmi na duševno zdravje pri delu*. <https://nijz.si/zivljenjski-slog/dusevno-zdravje/vpliv-vodenja-zaposlenih-z-ui-in-algoritmi-na-dusevno-zdravje-pri-delu/>
19. Parent-Rocheleau, X., & Parker, S. K. (2022). Algorithms as work designers: How algorithmic management influences the design of jobs. *Human resource management review*, 32(3), 100838. <https://doi.org/10.1016/j.hrmr.2021.100838>
20. Parker, S. K., & Grote, G. (2022). Automation, algorithms, and beyond: Why work design matters more than ever in a digital world. *Applied psychology*, 71(4), 1171–1204. <https://doi.org/10.1111/apps.12241>
21. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations and Directives (Artificial Intelligence Act). (2024). *Official Journal of the European Union*, L, 2024/1689. <https://eur-lex.europa.eu/eli/reg/2024/1689/oj>
22. Soulami, M., Benchechrout, S., & Galiulina, A. (2024). Exploring how AI adoption in the workplace affects employees: a bibliometric and systematic review. *Frontiers in artificial intelligence*, 7, 1473872. <https://doi.org/10.3389/frai.2024.1473872>
23. Van Eck, N. J., & Waltman, L. (2023). VOSviewer manual for version 1.6.20. Centre for Science and Technology Studies, Leiden University. https://www.vosviewer.com/documentation/manual_vosviewer_1.6.20.pdf
24. Vlada Republike Slovenije. (2026). *Nacionalna strategija umetne inteligence do leta 2030 (NsUI 2030)*. <https://www.gov.si/assets/ministrstva/MDP/DDD/NsUI2030.pdf>

25. Wang, H., Ding, H., & Kong, X. (2023). Understanding technostress and employee well-being in digital work: The roles of work exhaustion and workplace knowledge diversity. *International Journal of Manpower*, 44(2), 334–353. <https://doi.org/10.1108/IJM-08-2021-0480>
26. World Health Organization. (2019, May 28). *Burn-out an “occupational phenomenon”*: *International classification of diseases*. <https://www.who.int/news/item/28-05-2019-burn-out-an-occupational-phenomenon-international-classification-of-diseases>
27. Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational research methods*, 18(3), 429–472. <https://doi.org/10.1177/1094428114562629>

Tilen Medved je asistent na Univerzi v Mariboru, Fakulteti za organizacijske vede, na področju inženiringa poslovnih sistemov. Diplomiral in magistriral je na Fakulteti za organizacijske vede Univerze v Mariboru iz teme, povezane s področjem ergonomije, ki je njegovo glavno raziskovalno področje.

Prof. dr. Zvone Balantič je predavatelj na Univerzi v Mariboru, Fakulteti za organizacijske vede. Njegovo raziskovalno področje je interdisciplinarno in povezuje ergonomijo, strojništvo in medicino. Svoje izkušnje intenzivno prepleta z razvojem aplikativnih rešitev v realnem okolju. Od leta 2003 je predstojnik Katedre za inženiring poslovnih in produkcijskih sistemov. Je mentor študentom na vseh treh stopnjah študija ter aktiven v mednarodnem prostoru.

Abstract

Workload in the Age of AI: Research Trends

Research Question (RQ): How did research at the intersection of artificial intelligence, workload, and well-being develop between 2021 and 2025, and what bibliometric structure is revealed by publication trends, subject areas, institutions, keywords, international collaboration, and co-citation patterns?

Purpose: The purpose of this study is to bibliometrically map the recent development and structure of research at the intersection of artificial intelligence, workload, and well-being and to identify the most prominent disciplinary, institutional, and conceptual patterns.

Method: A bibliometric analysis was conducted on 399 documents indexed in Scopus and published between 2021 and 2025. The analysis covered annual publication output, subject areas, institutional distribution, keyword co-occurrence, country co-authorship, and cited-author co-citation. Bibliometric networks were created in VOSviewer 1.6.20 using full counting and association-strength normalization.

Results: Publication output increased sharply during the observed period, particularly in 2024 and 2025. The literature spans several research areas, with computer science, medicine, and engineering among the most represented. Keyword co-occurrence analysis identified five interconnected clusters linking AI and machine learning with mental and cognitive workload and human factors, clinical decision-making and healthcare, occupational stress and psychological well-being, healthcare worker burnout and digital health, and diagnostic and predictive approaches.

Organization: The study provides managers and practitioners with an overview of how research connecting AI, workload, and well-being is structured across disciplines and research topics. The findings can support the identification of areas that require closer consideration when AI is introduced into work processes.

Society: Mapping research on AI, workload, and well-being contributes to a clearer understanding of how worker-related issues are represented within the growing body of AI research and supports informed discussion of responsible AI use at work.

Originality: The study provides a focused bibliometric view of workload as a linking concept between artificial intelligence research and research on employee health and well-being.

Limitations / further research: The findings depend on Scopus coverage, the English-language restriction, the 2021–2025 time window, selected document types, search terms, and bibliometric thresholds. Bibliometric relationships indicate patterns in the literature but do not provide evidence of causal effects of AI on workload or well-being. Future studies may complement bibliometric mapping with systematic content analysis and empirical research.

Keywords: artificial intelligence, workload, job demands, occupational stress, work design, employee well-being, bibliometric analysis.



Articles in this journal are licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).



This journal is published by [Faculty of Organisation Studies in Novo mesto](https://www.fos.unm.si/).