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Determinants of Replacing Human Managers with AI-Driven Virtual Managers. Results of Research

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Abstract: Research on Artificial Intelligence (AI) in management is gradually emerging as one of the key challenges for the future, highlighting the need for effective cooperation between humans and AI agents within organizations. The implementation of AI in management appears to surpass any previous technological breakthrough in human history and it is viewed as a promising paradigm for addressing future scenarios in which humans and autonomous systems collaborate closely. The aim of this paper is to present the most significant determinants of replacing human managers with AI-driven virtual managers, particularly in relation to methodological challenges in management science, managerial work representation, research methods, research tools, and reasoning techniques. The research problem addressed in this paper concerns the feasibility of replacing human managers with AI-driven virtual managers, grounded in a new methodological approach referred to as the system of organizational terms. The study employs online management tools as research instruments and ChatGPT-5 as the primary reasoning method. Two research questions were explored: RQ1: Which managerial actions performed by humans can be effectively replaced by AI-driven managers in virtual teams? RQ2: What conditions must be met to ensure high accuracy and reliability of AI-driven managerial actions? The answers to these questions were formulated based on the original methodological framework for studying management reality and through empirical research on human managerial behavior using online management tools (TransistorsHead.com).

Keywords: artificial intelligence, artificial managers, the system of organizational terms, ChatGPT-5

Introduction

Over the past two decades, information technologies, robotics, and the automation of human labor through machines and algorithms have advanced rapidly. Today, managers routinely rely on digital tools that support the documentation and coordination of their work in logistics processes (Dash, McMurtrey, & Rebman, 2019), IT service environments (Keller, 2017), and team management practices (Davenport & Kirby, 2015). Yet despite this widespread technological integration, the prospect of replacing human managers with robotic ones remains largely unexplored in mainstream management discourse.

While it is commonly acknowledged that artificial intelligence (AI) can augment human capabilities in team settings, concrete frameworks for implementing AI-driven managerial practices are still underdeveloped (Flak & Pyszka, 2022). Research on AI indicates that it can strengthen human teams by enhancing coordination, increasing knowledge-sharing and learning, supporting decision-making processes, and improving team performance evaluation (Khakurel & Blomqvist, 2022). Furthermore, the emergence of large language models has accelerated the adoption of AI systems such as ChatGPT across industries, leading to notable productivity increases (Bouschery, Blazevic, & Piller, 2023).

Therefore, the research problem addressed in this paper concerns the feasibility of replacing human managers with AI-driven virtual managers, grounded in a new methodological approach referred to as the system of organizational terms. Two research questions were explored:

- RQ1: Which managerial actions performed by humans can be effectively replaced by AI-driven managers in virtual teams?
- RQ2: What conditions must be met to ensure high accuracy and reliability of AI-driven managerial actions?

The purpose of this paper is to examine the key factors shaping the potential replacement of human managers with AI-enabled virtual managers, with a particular focus on the methodological challenges facing management research. This includes issues related to how managerial work is conceptualized, the research methods and analytical tools applied, and the reasoning frameworks by ChatGPT 5.0.

The research method employed to address the research problem was a long-term non-participant observation conducted from December 18, 2023, to January 29, 2024, among students of the Faculty of Law and Social Sciences at Jan Kochanowski University in Kielce. Sixty participants worked in 12 virtual teams, completing project documentation for a YouTube-style "Talent Show" using ten online management tools provided on the TransistorsHead.com platform.

State of the art in managerial work representation

Due to the absence of a consistent and widely accepted epistemological foundation in management science, representations of team management have also remained fluid. The understanding of managerial work has evolved continuously since the emergence of scientific management. In the early 20th century, managers were primarily characterized by a set of classical functions - planning, organizing, motivating, and controlling - as outlined by Fayol (1916). For more than sixty years, research on managerial work and its theoretical representation has been shaped primarily by three dominant perspectives: managerial skills, managerial roles, and managerial styles.

Firstly, the discussion around managerial skills started with Koontz and O'Donnell's (1964) contribution, followed shortly by Katz's influential framework, which positioned managerial work in terms of skill sets. Katz (1974) defined managerial skill as the capacity to lead a team effectively and foster collaborative effort. His widely adopted typology distinguished three categories of skills: technical, interpersonal, and conceptual, each associated with different managerial levels, from supervisors to executives (Kaiser, Craig, Overfield, & Yarborough, 2011). Over the next decades, this perspective evolved, with contemporary classifications expanding to include competencies such as critical thinking, problem solving, data organization, conceptual reasoning, idea evaluation, and persuasive communication (Ullah, Burhan, & Shabbir, 2014).

Secondly, in the 1980s, Mintzberg advanced the view that managerial work can be understood through ten fundamental roles spanning interpersonal, informational, and decisional domains, applicable across organizational contexts. He defined a managerial role as a distinct set of jobs, related behaviors performed by managers (Mintzberg, 1980). His framework included roles such as figurehead, leader, liaison, monitor, disseminator, spokesperson, entrepreneur, disturbance handler, resource allocator, and negotiator. Building on this foundation, scholars introduced alternative role classifications, for example, leader, peer, conflict resolver, information distributor, decision maker, resource allocator, entrepreneur, and technician (Pavett & Lau, 1982), or explorer, organizer, controller, and adviser (McCann & Margerison, 1989).

Thirdly, leadership styles have been examined in management scholarship for decades, situated within broader discussions of leadership and the leader's role in teams. Drawing on classical management thought, it is defined managerial leadership as the process of directing and influencing the task-related activities of group members. This definition highlights three key aspects: leadership is inherently people-centered; it involves an unequal distribution of power between leaders and group members; and leaders not only issue directives but also shape the behavior and attitudes of subordinates (Stoner & Wankel, 1986).

Research on leadership has long focused on identifying leader traits and behaviors that enable effective leadership regardless of context. Fleishman et al. (1991) observed that most leadership style classification systems converge around two behavioral categories: task-focused behaviors, oriented toward task accomplishment, and person-focused behaviors, aimed at fostering interaction and supporting team development. Numerous empirical studies have explored leadership styles within this framework (Yeh & Hsieh, 2017). Task-oriented leadership behaviors typically include transactional leadership, structure initiation, and boundary spanning, whereas person-oriented leadership encompasses transformational leadership, empowerment behaviors, and motivational practices (Afsar, Badir, Saeed, et al., 2017). However, research grounded in managerial skills, managerial roles, and managerial styles does not provide a clear answer to the fundamental question of what managers actually do. As a result, these frameworks cannot serve as a sufficient basis for developing AI-driven artificial managers. Findings from the author's eighteen years of research indicate that a fundamentally different approach is required to represent managerial work.

Given the accelerating pace of work automation (McAfee & Brynjolfsson, 2016) and advances in pattern-recognition techniques (Zhang et al., 2017), addressing these issues becomes essential for establishing a theoretical foundation for automating team management. The author proposes such a foundation in the form of a system of organizational terms, developed and validated across multiple research projects. This is the first pillar of a theoretical framework related to capturing empirical data on team management.

This system consists of two core dimensions. The first is its philosophical underpinning, grounded in Wittgenstein's conception of the world as composed of facts and "states of affairs" (Brink & Rewitzky, 2002). Within this framework, team management is modeled through interactions between events and objects (Flak, 2019).

As illustrated in Figure 1, each event and object is encoded as n.m, where n denotes the element and m indicates its version. For example, event 1.1 produces object 1.1, which subsequently triggers event 2.1, leading to the creation of object 2.1. Concurrently, object 1.1 initiates event 3.1, generating object 3.1. Object 3.1 then activates event 1.2, resulting in an updated object - object 1.2. In this manner, managerial action unfolds through linked sequences of events and objects, such as event 1.1 paired with object 1.1.

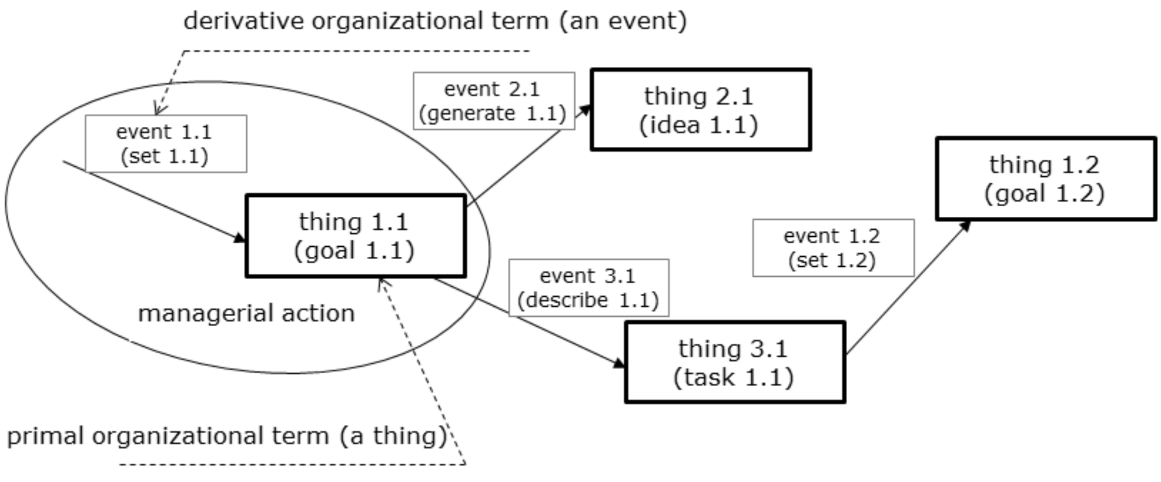

Figure 1. The fundamental structure of team management research

In order to replace human managers with artificial managers we have to reveal what managers actually do in practice and identify (1) the sequential flow of managerial actions and (2) the substantive content of those actions (Sinar & Paese, 2016). The key appears to lie in the relationship between managerial roles and managerial skills. To perform a given role, a manager must possess corresponding skills; roles are enacted through the routine activities enabled by those skills. Thus, managerial work manifests as concrete actions undertaken in the course of fulfilling roles and applying competencies. In this view, a managerial action can be understood as a tangible activity carried out by a manager to enact a managerial role and apply a specific managerial skill (Yang, Flak, & Grzegorzek, 2018).

From a logical point of view, organizational terms are grouped into two categories: primal and derivative. In this framework, things function as primal organizational terms and represent resources within the organizational reality, while events serve as derivative terms and represent processes. Consequently, the system integrates both the resource-based and process-oriented perspectives in the study of team management, capturing how managerial processes shape and transform team resources. As shown in Figure 1, this ontological structure enables a standardized representation of all managerial actions (Flak, 2019).

Research tools and methods

The second pillar of this theoretical framework related to capturing empirical data on team management is a set of research tools. A key premise is that data must be collected in a way that allows both managers and team members to be represented through their managerial actions. The most effective approach is to track these actions via the digital management tools that teams use in their everyday work (Flak, 2019). To support this, a research platform, TransistorsHead.com, was developed, featuring online tools that record information in (1) sequential and (2) content-based dimensions.

As illustrated in Figure 1, when a manager sets a goal (an action labeled Event 1.1 - set 1.1), the system records the attributes of Goal 1.1 across these three domains. Later, if the manager revisits the same goal. For example, after defining a task (describe 1.1 and task 1.1), they initiate a new instance of the management process. This generates updated attributes for the second version of the goal (set 1.2 and goal 1.2). The comparison between the feature sets of Goal 1.1 and Goal 1.2 provides insight into how the managerial process evolved over that period (Flak, 2022).

Importantly, the platform functions simultaneously as a research tool and a practical management tool. As managers and team members perform their tasks, the system continuously records changes in managerial actions, effectively creating a frame-by-frame representation of teamwork, such as a motion-capture record of managerial behavior in action.

The concept of observing managerial actions as a basis for research has precedents in earlier scholarship. Notably, time-and-motion studies (Barnes, 1980) have been applied in manufacturing settings (Al-Saleh, 2011), healthcare operations (Lopetegui et al., 2014), and manual labor processes (Magu et al., 2015), and to a limited degree in examining managerial work (Tengblad, 2002). This tradition traces back to the foundational work of Frank and Lillian Gilbreth in the early twentieth century, whose analysis of work motions marked the beginning of large-scale workforce automation (Karsten, 1996). Yet, efforts to capture team-level managerial actions with comparable breadth and precision have not previously matched the capabilities enabled by the system of organizational terms introduced here.

Using the system of organizational terms together with the TransistorsHead.com platform, the research captures and analyzes managerial actions over time, enabling the examination of similarities and patterns in team management processes.

Research results

The study was conducted as a long-term, non-participant observation designed to address the research problem outlined in the Introduction. It took place between December 18, 2023, and January 29, 2024, involving 60 students from the Faculty of Law and Social Sciences at Jan Kochanowski University in Kielce. Participants collaborated in 12 virtual teams and were tasked with developing project documentation for a YouTube-style "Talent Show" format. Teams were instructed to define an organizational challenge and propose a comprehensive solution, detailing both the program concept and an implementation plan. The final deliverable was a PDF report presenting the proposed solution and its key components.

During the project, participants interacted continuously with the management tools integrated into TransistorsHead.com (refer to Figure 1). The platform, grounded in the system of organizational terms, enabled detailed tracking of sequential managerial actions undertaken by team members. Each managerial action was recorded using a numerical coding scheme: 0 – no managerial action, 1 – setting goals, 2 – describing tasks, 3 – generating ideas, 4 – specifying ideas, 5 – creating options, 6 – selecting options, 7 – checking motivation, 8 – resolving conflicts, 9 – preparing meetings, 10 – explaining problems.

This study examined a real-time dataset of managerial behaviors performed within a virtual student project team. The dataset consisted of 2668 recorded managerial actions of a human manager, captured in one-second resolution, where each action represented the activation of one of 10 managerial tools (with an additional state "0" indicating no managerial action).

The first 1499 observations reflected authentic behavior of the human manager during the execution of the project. The remaining 1169 observations constituted AI-generated predictions produced by ChatGPT 5 using a semi-Markov sequence model trained exclusively on the initial human dataset, allowing direct comparison between real and predicted managerial trajectories.

Two parallel data streams were analyzed: (1) the time axis expressed in cumulative seconds marking the beginning of each managerial action; and (2) the categorical managerial tool identifier, indicating which managerial function was activated at a given moment (from 0 to 10, as mentioned above).

This design enabled assessment of both temporal accuracy (alignment of action timing) and behavioral accuracy (correct prediction of managerial function). By comparing real managerial behavior with model-generated behavior within the same task environment, the study evaluated the extent to which AI (ChatGPT 5) can replicate human managerial action patterns in the projects.

The analysis employed a deterministic semi-Markov modelling approach to predict managerial behavior on the basis of observed sequential activity data. The initial dataset consisted of 1499 timestamped managerial actions, each associated with a discrete managerial tool representing distinct managerial functions (e.g., goal-setting, conflict resolution, idea specification). First, transition frequencies between tools were calculated, producing an empirical one-step state transition matrix. This structure assumes that the probability of selecting the next tool depends on the currently active tool, consistent with first-order Markov chain theory, which has been widely used to model sequential human behavior and decision patterns (Howard, 1971; Kosinski, Stillwell, & Graepel, 2013).

Subsequently, the time intervals between transitions were computed to capture the temporal dynamics of behavioral change. For each observed transition pair (current tool and next tool), a median duration was estimated, allowing the model to reflect realistic temporal persistence in action states. When transition-specific time distributions were unavailable due to sparse data, a hierarchical fallback strategy was implemented: the model first applied medians associated with the next tool in general, and ultimately the global median transition duration across all states. This approach aligns with semi-Markov frameworks, which extend classical Markov models by explicitly modelling variable dwell times between state changes (Howard, 1971; Limnios & Ouhbi, 2016).

Using the learned transition structure and temporal parameters, the model generated 1169 additional sequential observations representing predicted future managerial actions, maintaining the empirical trajectory of managerial behavior. The result constitutes a probabilistically grounded yet deterministic simulation, reflecting observed managerial decision patterns and temporal rhythms within the task-driven collaborative setting.

To evaluate the predictive capacity of the semi-Markov behavior model, the forecasted managerial actions (n=1169) were compared to the corresponding real managerial actions recorded in the same time window. Two dimensions of behavior were assessed: (1) the sequence of managerial tools selected (categorical behavior) and (2) the timing of transitions between consecutive managerial actions (temporal behavior).

The accuracy of predicting the specific managerial action (tool selection) was 26,99%, meaning that approximately one in four actions chosen by the manager was correctly anticipated by the model. This level of accuracy indicates the presence of recognizable behavioral patterns in managerial actions but also confirms a substantial influence of situational, contextual, and cognitive factors not captured in the historical behavioral sequence alone. Such performance aligns with research showing that behavioral prediction models applied to managerial action sequences often achieve modest accuracy when context and semantic cues are unavailable (Kosinski, Stillwell, & Graepel, 2013; Wauters & VanHook, 2016).

In contrast, the temporal component demonstrated substantially lower alignment. The mean absolute error (MAE) between predicted and actual timestamps was 716855 seconds, and the root mean square error (RMSE) was 849282 seconds. These values reflect significant discrepancies in the timing of action transitions and suggest that while the manager's sequence of actions exhibits structural patterns, the duration of engagement in each managerial state is considerably more variable and influenced by task complexity, interactions within the team, and real-time project contingencies. Prior work has similarly highlighted high temporal variability in human cognitive and operational cycles (Howard, 1971).

Collectively, the results demonstrate that behavioral sequencing in managerial actions displays detectable regularities, whereas the timing of transitions remains highly context-dependent.

Addressing the first research question, which managerial actions performed by humans can be effectively replaced by AI-driven managers in virtual teams (RQ1), the findings suggest that, when comparing actual managerial behavior with AI-generated outputs, the strongest alignment occurred in the domain of describing tasks. In the empirical dataset, this action accounted for 26.99% of all recorded managerial actions, and the AI model reproduced this pattern consistently. By contrast, other behaviors appeared less frequently and exhibited substantial variability: generating idea (15.85%), creating options (12.25%), explaining problems (9.51%), solving conflicts (9.94%), setting goals (5.31%), checking motivation (2.74%), and preparing meetings (2.83%). These actions were not accurately predicted by the model, indicating high dependency on situational context and social judgement.

Overall, the results indicate that AI-driven management systems are most effective when handling structured, procedural, and task-oriented actions. Conversely, actions that are creative, strategic, or interpersonal in nature - such as generating ideas, making decisions, motivating team members, or resolving conflicts - remain predominantly human-driven, as they require adaptive reasoning, emotional perception, and subtle evaluative skills.

Responding to the second research question, what conditions must be met to ensure high accuracy and reliability of AI-driven managerial actions (RQ2), it can be inferred that the empirical evidence shows AI performs reliably only in structured, routine managerial actions, while its accuracy declines sharply in domains requiring creativity, interpersonal judgement, or strategic reasoning. This suggests that AI-driven managerial systems operate effectively in environments defined by procedural consistency, transparent task logic, and well-structured actions. However, as managerial actions become socially nuanced, ambiguous, or emotionally sensitive, predictive performance deteriorates. These results align with prior research indicating that AI excels in rule-based cognitive functions but remains constrained in context-dependent and socially complex managerial processes (Brynjolfsson & McAfee, 2017; Davenport & Kirby, 2016; Wilson & Daugherty, 2018).

Discussion

The results indicate that AI successfully replicated structured, repetitive managerial actions, particularly those focused on task clarification and description. It was unable to forecast behaviors grounded in creativity, interpersonal interaction, or discretionary judgment, such as generating ideas, checking motivation, and solving conflict. These findings are consistent with prior research showing that AI performs effectively in rule-governed, data-intensive, and routine action settings, but remains constrained in situations demanding social sensitivity, ambiguity management, and emotional discernment (Brynjolfsson & McAfee, 2017).

In this study, data were captured through online management tools that recorded managerial actions in real time, using a digital-trace approach comparable to methods employed for mapping human behavioral patterns. While these logs offer objective and time-stamped observations, they do not incorporate contextual or emotional information, which restricts predictive performance in socially nuanced managerial situations (Kosinski, Stillwell, & Graepel, 2013; Junger, 2017).

Comparable research in project-based environments similarly shows that AI performs reliably in planning, scheduling, and forecasting tasks, yet struggles to substitute for human leadership in dynamic, collaborative team contexts (Bento et al., 2022; Wauters & VanHook, 2016).

Conclusions

This study addressed the feasibility of replacing human managers with AI-driven managers, employing a novel methodological framework based on the system of organizational terms.

The findings demonstrate that AI-driven managers can reliably replicate only structured, routine, and task-focused managerial behaviors, most notably those related to task clarification and procedural coordination. These actions follow explicit logic, clear workflows, and stable rules, making them suitable for automation. However, managerial actions involving creativity, motivation, conflicts, and judgment remain resistant to AI substitution. In these domains, performance declines due to the need for contextual awareness, emotional sensitivity, and adaptive reasoning.

In conclusion, the replacement of human managers by AI is feasible only within narrowly defined, highly structured domains of managerial practice. Rather than full substitution, the findings point toward a hybrid paradigm in which AI supports operational tasks while humans retain responsibility for interpretive, relational, and strategic aspects of leadership. Future research should deepen the methodological foundation for analyzing managerial action and explore integration models that combine computational precision with human cognitive and social capabilities.

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References

Al-Saleh, K. S. (2011). Productivity improvement of a motor vehicle inspection station using motion and time study techniques. *Journal of King Saud University – Engineering Sciences, 23,* 33–41. https://doi.org/10.1016/j.jksues.2010.01.001

Afsar, B., Badir, Y. F., Saeed, B. B., & Hafeez, S. (2017). Transformational and transactional leadership and employees' entrepreneurial behavior in knowledge-intensive industries. *The International Journal of Human Resource Management, 28*(2), 307–332. https://doi.org/10.1080/09585192.2016.1244893

Barnes, R. M. (1980). *Motion and time study: Design and measurement of work (7th ed.).* John Wiley.

Bento, S., Pereira, L., Gonçalves, R., Dias, Á., & Lopes da Costa, R. (2022). Artificial intelligence in project management: Systematic literature review. *International Journal of Technology Intelligence and Planning, 13*(2), 143–163. https://doi.org/10.1504/IJTIP.2022.10050400

Bouschery, S. G., Blazevic, V., & Piller, F. T. (2023). Augmenting human innovation teams with artificial intelligence: Exploring transformer-based language models. *Journal of Product Innovation Management, 40*(2), 139–153. https://doi.org/10.1111/jpim.12656

Brink, C., & Rewitzky, I. (2002). Three dual ontologies. *Journal of Philosophical Logic, 31*(6), 543–568. https://doi.org/10.1023/A:1021204628219

Brynjolfsson, E., & McAfee, A. (2017). *Machine, platform, crowd: Harnessing our digital future.* W. W. Norton & Company.

Dash, R., McMurtrey, R., & Rebman, C. (2019). Application of artificial intelligence in automation of supply chain management. *Journal of Strategic Innovation & Sustainability, 14*(3), 43–53. https://doi.org/10.33423/jsis.v14i3.2105

Davenport, T. H., & Kirby, J. (2016). Beyond automation: Strategies for remaining gainfully employed in an era of very smart machines. *Harvard Business Review, 94*(6), 58–65.

Fayol, H. (1916). *Administration industrielle et générale.* Dunod.

Fleishman, E. A., Mumford, M. D., Zaccaro, S. J., Levin, K. Y., Korotkin, A. L., & Hein, M. B. (1991). Taxonomic efforts in the description of leader behavior: A synthesis and functional interpretation. *Leadership Quarterly, 4,* 245–287. https://doi.org/10.1016/1048-9843(91)90016-U

Flak, O. (2019). System of organizational terms as a methodological concept in replacing human managers with robots. Lecture Notes in Networks and Systems, 70, 479–500. https://doi.org/10.1007/978-3-030-12385-7_36

Flak, O. (2022). Impact of artificial management on the work of a team of humans: Result of research. *Organization and Management, 162,* 153–166. http://doi.org/10.29119/1641-3466.2022.162.8

Flak, O. (2023). Ontology of online management tools aimed at artificial management implementation: An example of use in software design. In H. Kaindl, M. Mannion, & L. Maciaszek (Eds.), *Proceedings of the 18th International Conference on Evaluation of Novel Approaches to Software Engineering* (ENASE 2023) (pp. 621–628).

Flak, O., & Pyszka, A. (2022). Evolution from human virtual teams to artificial virtual teams supported by artificial intelligence: Results of literature analysis and empirical research. *Management Issues, 20*(2), 48–69. https://doi.org/10.7172/1644-9584.96.3

Howard, R. A. (1971). *Dynamic probabilistic systems: Volume I – Markov models.* Wiley.

Kaiser, R. B., Craig, S. B., Overfield, D. V., & Yarborough, P. (2011). Differences in managerial jobs at the bottom, middle, and top: A review of empirical research. *The Psychologist-Manager Journal, 14*(2), 76–91. https://doi.org/10.1080/10887156.2011.570137

Karsten, L. (1996). Writing and the advent of scientific management: The case of time and motion studies. *Scandinavian Journal of Management, 12*(1), 41–55. https://doi.org/10.1016/0956-5221(95)00040-2

Katz, R. L. (1974). Skills of an effective administrator. *Harvard Business Review, 52*(5), 90–102.

Keller, A. (2017). Challenges and directions in service management automation. *Journal of Network & Systems Management, 25*(4), 884–901. https://doi.org/10.1007/s10922-017-9437-9

Khakurel, J., & Blomqvist, K. (2022). Artificial intelligence augmenting human teams: A systematic literature review on the opportunities and concerns. In H. Degen & S. Nato (Eds.), *Artificial Intelligence in HCI* (Vol. 13336, pp. 51–68). Springer. https://doi.org/10.1007/978-3-031-05643-7_4

Kosinski, M., Stillwell, D., & Graepel, T. (2013). Private traits and attributes are predictable from digital records of human behavior. *Proceedings of the National Academy of Sciences (PNAS), 110*(15), 5802–5805. https://doi.org/10.1073/pnas.1218772110

Koontz, H., & O'Donnell, C. (1964). *Principles of management.* McGraw-Hill.

Magu, P., Khanna, K., & Seetharaman, P. (2015). Path process chart: A technique for conducting time and motion study. *Procedia Manufacturing, 3*, 6475–6482. https://doi.org/10.1016/j.promfg.2015.07.929

McAfee, A., & Brynjolfsson, E. (2016). Human work in the robotic future: Policy for the age of automation. *Foreign Affairs, 95*(4), 139–150.

Mintzberg, H. (1980). *The nature of managerial work.* Prentice-Hall.

Pavett, C. M., & Lau, A. W. (1983). Managerial work: The influence of hierarchical level and functional specialty. *Academy of Management Journal, 26*(1), 170–177.

Spriegel, W., & Myers, C. (1953). *The writings of the Gilbreths.* (Uzupełnij wydawnictwo jeśli masz)

Stoner, J. A. F., & Wankel, C. (1986). *Management (3rd ed.).* Prentice-Hall.

Tengblad, S. (2002). Time and space in managerial work. *Scandinavian Journal of Management, 18*(4), 543–565. https://doi.org/10.1016/S0956-5221(01)00031-8

Ullah, F., Burhan, M., & Shabbir, N. (2014). Role of case studies in development of managerial skills. *Journal of Managerial Sciences, 8*(2), 192–207.

Wauters, M., & Vanhoucke, M. (2016). A comparative study of artificial intelligence methods for project duration forecasting. *Expert Systems with Applications, 46,* 249–261. https://doi.org/10.1016/j.eswa.2015.10.008

Wilson, H. J., & Daugherty, P. R. (2018). *Human + machine: Reimagining work in the age of AI.* Harvard Business Review Press.

Yang, C., Flak, O., & Grzegorzek, M. (2018). Representation and matching of team managers: An experimental research. *IEEE Transactions on Computational Social Systems, 5*(2), 311–323. https://doi.org/10.1109/TCSS.2018.2812825

Yeh, C.-H., & Hsieh, T.-Y. (2017). Management styles and job satisfaction in Taiwan's architectural firms. *International Journal of Organizational Innovation, 10*(1), 185–201. https://doi.org/10.14807/ijmp.v12i4.1363

Zhang, J., Williams, S. O., & Wang, H. (2017). Intelligent computing system based on pattern recognition and data mining algorithms. *Sustainable Computing: Informatics and Systems,* 1–11. https://doi.org/10.1016/j.suscom.2017.10.010