Cognitive Computing and Internet of Things, Vol. 124, 2024, 114–122
https://doi.org/10.54941/ahfe1004709

Democratization in Industry via Multi-Agent Systems? The Case of a Production Company

Noushin Gheibi and Stefan Böschen

Human Technology Centre, RWTH Aachen University, Aachen, 52062, Germany

ABSTRACT

Democracy is typically a question of political government. Nevertheless, in recent years, the forms of democratic development have changed in the course of the governance debate. According to Council of Europe, E-democracy tools use technology to boost key democratic values like participation, inclusivity, efficiency, effectiveness, transparency, openness and accountability within the democratic system. Alongside civil society, companies are playing an increasingly important role in the establishment of collective order. The difficult aspects of this development can be seen in the concentration of market power and the circumvention of employee co-determination. At the same time, however, Small and Medium Enterprises (SME) sometimes take on the role of pioneers. One key example is about AI-based decision support systems in order to realize new decision-making and co-determination opportunities. This raises the question of what potential for democratization and, if so, in what form, is actually emerging here. On the one hand, this article raises the question of how aspects of a "democratization" in companies can be realized and presents a conceptual approach for analysing such ambitions. On the other hand, specific challenges of a "democratization" via digital tools will be worked out by analysing the case study of a SME. An important result is that forms of democratization via multi-agent systems are only perceived as democratic if they are introduced and procedurally anchored within the company through social processes that are perceived as legitimate.

Keywords: Democracy, SME, Democratization via digital tools, Multi-agent systems

INTRODUCTION

Individuals strive for democracy within every entity to actively participate in decisions that impact them, contribute meaningfully to the community they belong to, and assert their presence and importance (Bachrach, 1967, Butzlaff, 2023, Nabatchi, 2012). Although the forms of democracy may undergo changes over time, the inherent feelings elicited by democracy remain unchanged; even with the expansion of digitalization and its impact on democracy, questions of participation, representation, or transparency are becoming more decisive than ever (Stratu-Strelet et al., 2023, Pantazi et al., 2022). Digitalization also transforms how workplaces function, so while hierarchical organizations are typically not the ideal environment for democratic decision-making, stakeholders and managers of companies

endeavour to pioneer the adoption of new technologies, fulfilling democratic decision-making in workplaces (Charles et al., 2022, Hilton et al., 2021, Dingwerth et al., 2020). In the meanwhile, studies also acknowledged that democratic and participative approaches can effectively function within workplaces (Reuten, 2021); so, in this context, democratization via digital tools and its utilization in the workplaces opens up new possibilities and raises significant questions, demanding additional examination. Thus, this paper explores the question of democratization in companies using Multi-Agent Systems by analysing a case study conducted within a globally diverse manufacturing SME.

Driven by the aim of Democratization of Decision-Making in Socio-Technical Settings, our empirical investigation involved conducting interviews with a selected cohort of eight employees from various divisions and hierarchical levels within the SME, facilitating a comprehensive exploration of multifaceted perspectives.

In this paper, dimensions of the decision-making process are first outlined based on a case study, followed by the presentation of a concept for democratization via Multi-Agent Systems (MAS), and ultimately, some general remarks based on the findings as well as an outlook on our further research.

Methods

In this study, we employed a case study approach to examine the dynamics of democratization in industry through Multi-Agent Systems and to explore the contextual situation for implementing a Decision-Support System (DSS) within an SME (Yin, 2014). The case study focused on a comprehensive analysis of a specific production company, which initially involved verifying operational documentation describing workflow procedures through exploration of specified scenarios. The first scenario, 'Automated test building,' begins with a new product order or the need for a production process update, facilitated by the program manager and forwarded to the automation engineer during the design phase. Another significant scenario, 'Worker allocation,' occurs prior to or during shifts, based on the assessment of workers' abilities and the production plan. Additionally, in the 'Machine maintenance' scenario, triggered by breakdowns or failures during the execution phase, known problems are addressed through a ticketing system.

Our research encompassed first a document analysis, second a visit of various departments within the company, beginning with an examination of company products and production halls, where ongoing tasks such as quality checks, labelling, identification, and evaluation were looked at with the method of participatory observation. Subsequently, attention shifted to the operation of collaborative robots with human involvement. Third, we conducted interviews with employees across different hierarchical positions and levels of experience ($N = 8$). However, this represents only the first round of interviews, with plans for a second wave later this year. Moreover, workshop formats will be used to deepen the insights for the alignment of the results

of the sociological analysis towards the development of the Multi-Agent Systems. It should be acknowledged that the results reported here are based on the first step of our case study.

Understanding Decision-Making Processes for Developing Decision Support Systems

To optimize the decision-support system towards a form of democratic decision-making, it is essential to closely examine the daily work routines of employees within the SME, along with their individual decision-making processes. To achieve this, eight interviews were conducted with staff across the organizational hierarchy, encompassing managerial personnel, supervisors and technicians from logistics and production teams, in addition to representatives from the workers' council, inquiring about their decision-making situations, associated problems, and characteristics. Additionally, participants, whose experiences vary from 2 years to more than 10 years, were invited to discuss their involvement within the company, sharing their opportunities for objection and suggestion, as well as addressing the status of decision-making transparency and the significance of trust. Moreover, their expectations from a decision support system and potential functionalities to optimize its performance were explored. Thus, in the following sections, we investigate deeper into the insights gained from the interviews, focusing on three key dimensions: decision-making, involvement, and expectations, subsequently examining their respective categories. Each aspect offers valuable perspectives shared by participants, revealing finer details of developing a democratic decision support system within the organization.

Decision-Making

Given that research indicates new technologies can enhance decision-making, it is essential for this study to obtain a clear understanding of the current decision-making processes within the SME (Rajagopal et al., 2022). This includes identifying whether decision-making follows a traditional or flat structure, evaluating the types of decisions made, assessing the effectiveness of the current process, understanding the challenges faced during decision-making, and recognizing the factors employees should consider in their decision-making approach. According to participants, decision-making situations can vary, ranging from decisions regarding the production line, such as assessing the authenticity of machine failure, determining when to report recurring errors to the supervisor, and potentially shutting down the line, to addressing stock differences or product shortages affecting production. These situations may also involve attributing fault, whether to internal parties, customers, or transport companies, in cases such as product failures and transport damage, and deciding whether to dismantle material returns. Moreover, decisions may involve personnel matters like overtime management, task allocation, and determining roles and timing for redundancy. Additionally, managerial and works council decisions may include adjusting budget allocations, managing staffing levels, handling dismissals, and addressing employee issues.

Based on statements from interviews, in the decision-making process, employees may face various challenges, with one of the most crucial being feelings of uncertainty regarding decision accuracy. This uncertainty may arise due to a lack of experience or insufficient information about the system, components, customer, employees, and timestamps. Consequently, the uncertainty presents itself differently: experienced individuals tend to accept the consequences, while amateurs often experience significant stress. Uncertain decisions can also jeopardize production line stability, particularly when made amidst disparities. These situations can become even more challenging, especially when superiors or experts are unavailable for consultation or conversely when multiple decision-makers hold differing ideas, resulting in slower progress in the production line. Other issues that may affect the decision-making process include work and time pressure, planning weekend work shifts, decisions with partial fairness, and budget constraints, which can lead to project cancellations.

In light of the mentioned situations and challenges, certain qualities and characteristics define the decision-making process within the SME. These include carefulness in decision-making and, notably, consideration of risks, and subsequently accepting their responsibility. In addition to utilizing the skills matrix, which outlines employee task assignments, supervisors should also take into account shift scheduling and workload when making decisions. Considering the priority of tasks is also crucial, as it determines the allocation of responsibilities, whether to highly qualified individuals or to those with lower experience. Based on the interviews, it was also found that most tasks in the company are repetitive, with rare occurrences of new tasks. This could explain why decision-making relies more on experiential knowledge, prompting employees with less experience to frequently seek guidance from their supervisors to ensure the accuracy of their decisions. While decisions are primarily reached collectively through discussions and regular meetings, hierarchical decision-making, particularly at the managerial level, is also observed.

Involvement

Involving employees in decision-making not only significantly enhance organizational efficiency but also fosters their creativity and commitment (Charles et al., 2021). Consequently, involvement is evaluated based on three key components: the opportunities for employee's objection and suggestion, the methods of transparency regarding decisions made, and the importance of trust among team members; which are interrelated concepts according to research findings (Rawlins, 2008, Grates, 2007, Chene and Chr, 2011). The interviewees highlighted that suggestions and objections receive primary consideration when they contribute to enhancing production or when failures or problems are identified in the production process. Additionally, while the ideas are conveyed to the management team through supervisors, annual employee discussions also provide an opportunity for individuals to express their views directly. Moreover, opinions regarding staff assignment planning can be widely acknowledged. Surprisingly, some employees may refrain from

offering suggestions or objections, arguing that intervening in superiors' decisions is not expedient, and that everyone should focus solely on their own work, believing this approach leads to a stress-free environment.

The responses to transparency questions can be divided into two categories: On one hand, decision-making transparency can be achieved through explanations from experts, addressing uncertainties raised by employees, clarifying new themes and decisions during weekly and monthly meetings, involving all relevant staff in decision-making, and fostering expertise and knowledge among the team over time. On the other hand, the transparency of decisions is context-dependent, and in certain cases, some decisions, particularly those at managerial levels, may not require understanding by others.

The participants emphasized the high level of trust among the team, highlighting that without trust in their team members, progressing in the work process would be impossible. They remarked that this existing trust minimizes the need for negotiation on every subject, thereby accelerating the work process. Direct interaction between team members was cited as a key factor in increasing trust, leading employees to have complete trust in their superiors due to awareness of their knowledge and experiences. Additionally, system functioning contributes to building trust between superiors and employees. However, mismatches between decisions reached and their implementation in the workplace were noted to harm the trust employees have in their superiors.

Expectations

An essential purpose of this study is exploring optimization prospects for a decision support system while considering the experiential insights of employees engaged in the workflow. To achieve this goal, the third dimension investigates participants' expectations of this system with the aim of simplifying, accelerating and ensuring the work process. Given that the primary objective of a decision support system is to simplify workflow by offering solutions, it is crucial for interviewees to have access to multiple proposed solutions for various scenarios. Recognizing work and time pressures as key challenges in decision-making, employees express a preference for reduced human intervention and alleviated time pressure through the digitalization of time-consuming and effortful tasks; For instance, the systematic categorization of the severity of various incoming errors would allow employees to easily identify the appropriate course of action when encountering specific types of errors. This approach would bypass the necessity for extensive time allocation to initially determine the error type, thereby reducing uncertainty in decision-making processes. Additionally, there is a desire for data within the system to be organized in a comprehensible manner, especially considering the vast amount of data across the entire company. Providing self-familiarization tools for both new hires and existing staff with the workflow is also seen as essential for facilitating the work process. Another highlighted point focuses on relieving employees and reducing workload by delegating risk assessment tasks to the system. Within this context, decision-makers

also express a desire to automate fault attribution processes, potentially by establishing specific criteria to streamline the determination of responsibility for particular damages or errors, thereby simplifying decision-making procedures.

The expressed expectations encompass points aimed at accelerating the work process. Recognizing staff assignment planning as a particularly time-consuming task, especially on weekends, underscores the necessity of implementing an automated system for assignment planning to assist supervisors, thereby significantly enhancing workflow efficiency and alleviating work-related pressure. Moreover, considering the aforementioned work pressure within the company and the potential for oversight regarding certain tasks and deadlines, employees have proposed the implementation of a signalling reminder system for upcoming plans. Additionally, access to a well-defined procedural framework would reduce challenges in finding experts and supervisors for consultations, thus furthering the acceleration of the work process. Other strategies, such as personally managing vacations and sick leave arrangements, along with task assignments tailored to individual preferences and competencies, serve to increase workflow efficiency. In addition, the implementation of automated customer service functionalities, such as email drafting, has the potential to mitigate time pressure. From a more technical perspective, it is advantageous to establish a structured inspection sequence for prioritizing error, enabling employees to accelerate the identification of the primary issue and address other errors effectively. The fulfilment of these requisites not only fosters punctuality but also enhances staff productivity and creativity.

The expectations articulated by the 8 interviewees regarding their anticipated functionalities of this system can significantly contribute to the decision support system's development and ensure the effectiveness of its workflow processes. The suggestions provided underline the critical need for accessing precise and reliable solutions, alongside secure access to all production and employee data. Therefore, establishing a comprehensive database containing all relevant company information is imperative. Additionally, enabling data and workflow reviews can enhance the accuracy of system data and contribute to the efficiency of the decision-making process. Moreover, it is essential to provide insights into the consequences of proposed solutions, ensuring a thorough understanding of potential outcomes. Indicating resource availability and their precise whereabouts through system would ensure the progression of workflow processes, covering aspects such as product, machinery and even substitute employee availability. From another perspective, employees anticipate that the integration of a decision support system would ensure equitable treatment for all staff members. However, the comprehensiveness of this system should not hinder critical thinking, as creativity and innovation must remain essential. Finally, there is an emphasis on protecting human discretion, recognizing the value of human judgment and autonomy within decision-making frameworks. Particularly, the participants envision the system as a tool that provides guidance, with ultimate decisions resting in human hands.

CONCLUSION

This paper undertakes an exploration of industrial democratization through Multi-Agent Systems, focusing specifically on a case study of a production company. Through the utilization of a comprehensive methodology involving documentary analysis, observations, and interviews, we have acquired valuable insights into the current decision-making processes, the degree of employee engagement within SMEs, as well as the anticipated functionalities of a decision support system by employees. The findings underscore the need for the development of a robust decision support system to initially offer production-line responsible persons a diverse array of solutions, thereby facilitating informed decision-making. Subsequently, such a system can serve as a tool to provide relevant data, whether related to workforce assignment plans, customer data, inventory management, or other important factors such as components, employees, and timestamps. Providing data, solutions, and the experienced consequences via a system allows to asses superiors' experience and simplifies the familiarization process for each newly hired employee. Moreover, they get enabled to gain sufficient confidence to make informed decisions. The implementation of such a system, coupled with the delegation of tasks and responsibilities to the system, shows potential for alleviating existing workloads and time pressures, ultimately fostering employee productivity and innovation across all organizational levels.

With regard to the exploration of employee involvement, we found that the dominant high level of trust among team members has led to a decreased tendency to raise objections or offer suggestions. However, there is a desire for self-management of personal time-off (PTO) and task assignments through the system. Despite the presence of a strong level of trust within the team, such trust may be weakened in instances where a mismatch arises between decisions reached collectively and their subsequent implementation within the company. However, with the implementation of a decision support system, such problems can be addressed, as they may arise from the involvement of several decision-makers, each with potentially conflicting perspectives and suggestions. In addition, the analysis of outcomes within the involvement dimension indicates that decisions made at the shop floor level are typically characterized by a higher degree of transparency, often resulting from regular meetings, active inquiry, and the inclusive participation of all relevant staff members. Conversely, decisions formulated at the upper management level are less frequently perceived as transparent to the entire staff. Furthermore, notably, employees view the decision support system as a supplementary tool, rather than a replacement for human decision-making.

However, there is a tension emerging. The tension between the needs and ambitions of the ones being represented in the decision support tool and the forms and logics of representing within the tool. This tension can be seen as the litmus test of the development of these kinds of tools. If there are no further options to get an insight or to intervene into the ways of being represented, the tool's legitimacy is at risk. In alignment to this, the workers express a firm belief that such a system should not take away their autonomy in decision-making but should instead enhance their ability to make informed,

efficient, and simplified decisions. The consensus among employees is that the decision support system should act as a guiding mechanism, providing insights and recommendations to facilitate improved decision-making processes, while the ultimate responsibility for decision-making remains with human actors.

ACKNOWLEDGMENT

This work has been supported by the FAIRWork project (www.fairwork-project.eu) and has been funded within the European Commission's Horizon Europe Programme under contract number 101069499. This paper expresses the opinions of the authors and not necessarily those of the European Commission. The European Commission is not liable for any use that may be made of the information contained in this paper.

Thank you to everyone who played a part in this project. Followed by.

Johannes Zysk, Johanna Werz, Lucas Paletta, Jochen Mosbacher, Roland Sitar, Martin Pecnik, Julia Tschuden, Herwig Zeiner, Sylwia Olbrych, Gustavo Vieira.

REFERENCES

Bachrach, P. J. 1967. The theory of democratic elitism: A critique.

Butzlaff, F. J. P. S. R. 2023. Consenting participation? How demands for citizen participation and expert-led decision-making are reconciled in local democracy. 21, 340–356.

Charles, J., Francis, F. & Zirra, C. J. A. O. B. R. 2021. Effect of employee involvement in decision making and organization productivity. 9, 28–34.

Charles, L., Xia, S. & Coutts, A. P. J. I. L. O. R. 2022. Digitalization and Employment. 1–53.

Chene, M. J. T. I. & Chr, M. I. 2011. Good practice in strengthening transparency, participation, accountability and integrity.

Dingwerth, K., Schmidtke, H. & Weise, T. J. E. J. O. I. R. 2020. The rise of democratic legitimation: why international organizations speak the language of democracy. 26, 714–741.

Grates, G. 2007. Edelman Trust Barometer 2007. Edelman.

Hilton, S. K., Arkorful, H. & Martins, A. J. M. R. R. 2021. Democratic leadership and organizational performance: the moderating effect of contingent reward. 44, 1042–1058.

Nabatchi, T. 2012. *A manager's guide to evaluating citizen participation*, IBM Center for the Business of Government Washington, DC.

Pantazi, M., Papaioannou, K. & van Prooijen, J. W. J. P. P. 2022. Power to the people: The hidden link between support for direct democracy and belief in conspiracy theories. 43, 529–548.

Rajagopal, N. K., Qureshi, N. I., Durga, S., Ramirez Asis, E. H., Huerta Soto, R. M., Gupta, S. K. & Deepak, S. J. C. 2022. Future of business culture: an artificial intelligence-driven digital framework for organization decision-making process. 2022, 1–14.

Rawlins, B. R. 2008. Measuring the relationship between organizational transparency and employee trust.

Reuten, G. 2021. The employment performance of the Mondragon worker cooperatives 1983–2019.

Stratu-Strelet, D., Gil-gómez, H., Oltra-Badenes, R. & Oltra-Gutierrez, J. V. J. J. O. B. R. 2023. Developing a theory of full democratic consolidation: Exploring the links between democracy and digital transformation in developing eastern European countries. 157, 113543.

Yin, R. K. 2014. *Case study research: Design and methods (applied social research methods)*, Sage publications Thousand Oaks, CA.