# A Bibliometric Analysis Deconstructing Research on how Digitalisation Affects Knowledge Workers

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**Abstract**: Whereas previous waves of automation have predominantly affected labour intensive work, current cognitive technologies enable automation and commoditization of knowledge intensive work. However, extant research provides limited understanding of how this man-machine collaboration will unfold. Moreover, knowledge intensive firms, such as professional service firms, are characterized by how professionals show a preference for autonomy, exhibiting a distaste for control, supervision, and formal organizational processes. Therefore, it is particularly prudent to investigate how knowledge workers will be affected by the introduction of technologies like AI, IoT and Big Data, giving special attention to their professional autonomy. However, there exist limited empirical studies on how the interaction between autonomous professionals and machines unfold in practice, and there exist no unifying theory explaining the effect of digitalization on this type of knowledge intensive work. To provide a starting point for subsequent research, we offer a structured literature review aided by a bibliometric analysis to identify core contributions that can identify and synthesize main dimensions in extant research. We experimented with different searches phrases at Web of Science, and ended up with combining (Digi* OR techno*) AND autonomy, which resulted in 3961 articles. By excluding irrelevant categories our result was 815 articles. We then performed a bibliometric analysis aided by VOSviewer and narrowed our dataset down to 15 core articles. A content analysis of these core articles identified three different goals of digital implementation; digital tools to enhance communication and sharing of information, digital tools for better decisions and digital tools for monitoring and control. We found paradoxical relations regarding worker autonomy and technology within all three goals. The content analysis points in the direction that the increased control following the new technology dominated the gained autonomy for knowledge professionals. We found three dominating factors that could be used to explain how the professionals perceived the change in autonomy. These are; what kind of job, what kind of technology and the professional's attitude towards social status, technology, change and knowledge sharing. We suggest that practitioners who are implementing digital technologies must pay attention to relations that affect knowledge professionals perceived autonomy.

**Keywords**: Bibliometric analysis, Digitalization, Knowledge intensive work, Knowledge worker autonomy

## 1. Introduction

This paper offers a bibliometric analysis of prior published research addressing the autonomy paradox. The aim of this study is to explain how digitalization affect knowledge worker autonomy. Researchers have previously explored the interactions between man and machine, yet the accelerating digitalization creates new socio-technical relations, which makes further investigation pertinent (Drangsholt, 2014; Sannes and Andersen, 2018; Hermansen, 2017; McKinsey, 2017). As opposed to previous industrial revolutions, technologies such as Internet of things (IoT), Artificial intelligence (AI) and Big Data enables automation of complex and cognitive tasks (McAfee and Brynjolfsson 2014; Shrouf, et al., 2014). The effects digitalization has on knowledge worker autonomy is found to be contradictory. Mazmanian, et al. (2013) named this phenomenon "The autonomy paradox". This term emerges from findings that displayed paradoxal relations regarding the implementation of digital communication tools. On the one hand, knowledge workers experienced an increased autonomy, by receiving greater flexibility and control. On the other hand, increased workload and surveillance resulted in weakened worker autonomy (Mazmanian, et al., 2013). Similar paradoxal relations have been reported in other studies, also by utilizing other digital tools (Underthum and Steen, 2018; Brey, 1999; Gerten, et al., 2018).

Knowledge workers, such as management consultants, lawers, and physicians are characterized by their preference for professional autonomy, social status and esoteric knowledge. These workers also exhibit a distaste for supervision and control (Nordenflycht, 2010). Being that knowledge workers are experts, they often possess more knowledge than their supervisors, within their field of knowledge (Newell, et al., 2009). Thus, organizations may benefit from offering professional autonomy to their knowledge workers. Experts predicts that the future jobs will consist of complex problem solving and highly educated workers (Butollo, et al., 2018; Bonekamp and Sure, 2015). Further, millennials demand autonomy (Morgan, 2015), but also expects guidance on how to perform their job (Cognizant, 2012). These relations amplify the importance of addressing "The autonomy paradox".

Given the lack of consensus regarding how digitalization will affect knowledge-intensive work, and predictions concerning future work, we want to address the following research question: *"How can a bibliometric analysis of extant research addressing digitalization contribute to understand the autonomy paradox, and which factors should leaders consider when implementing new digital technologies in knowledge intensive firms?"*

To explore the research question, we conducted a literature review, aided by bibliometric analysis. We carried out a structured literature search by utilizing the ISI Web of Science's database, and the search phrases (Digi* OR Techno*) AND Autonomy. We carefully selected relevant categories and ended up with a database consisting of 815 articles. Further, we identified 15 core articles based on subjective and objective criteria. Finally, through a content analysis of our 15 core articles we identified three levels of digitalization, which have different impact on knowledge worker autonomy. Paradoxical relations between the implementation of hardware, systems, and algorithms, and worker autonomy, emerged. The findings indicates that increased control and monitoring following technological implementations, dominates the gained autonomy. We discovered two main factors that could be used to explain how knowledge workers perceive the change in autonomy: what technology, and the knowledge worker's attitude towards social status, technology, and knowledge sharing. Knowing this, we can provide change agents with valuable insight when implementing new technologies. This study has also extended the current understanding regarding this topic, which paves the way for further research. We present a framework identifying three levels of digitalization; each with different consequences for knowledge worker autonomy and related managerial considerations within.

## 2. Theory

The paradoxical relations between autonomy and control that emerged by using digital tools, has been named "The autonomy paradox" (Mazmanian, et al., 2013). In their study, Mazmanian, et al. (2013) found that the utilization of mobile email devices, on the one hand, offered knowledge workers flexibility and greater control over their own work. On the other hand, increased availability interfered with the work-life balance. Paradoxical relations were addressed already before the millennium (Brey, 1999). Technologies that enabled employees to work from home, offered flexible work hours, but also increased surveillance and standardization of tasks, which pulls the autonomy in different directions. Similar findings have been presented elsewhere in the literature (Underthun and Steen, 2018; Gerten, et al., 2018). Digital systems can enhance information sharing and transparency, which may empower workers and shift responsibility through the organization (Bouèe, 2015). Still, this also facilitates increased control and monitoring (Underthun and Steen, 2018; Gerten, et al., 2018).

Professionals, such as physicians, consultants, and lawyers are workers that traditionally enjoy autonomy, and express a distaste for surveillance and control (Nordenflycht, 2010). Further, autonomy is a job characteristic that is central in predicting the job satisfaction of a knowledge worker (Eaton-Wally and Lowe, 2017). Within their field of expertise, knowledge workers are often superior to their supervisors, thus giving them autonomy may be very valuable to the firm (Newell, et al., 2009). Being that the service knowledge workers deliver is specialized and hard to measure (Løwendahl, 2005), many believe that knowledge intensive work is beyond computerization (Christensen, et al., 2013; Frey and Osborne, 2013). Still, these claims are being challenged.

Automation of tasks, aided by AI and Big Data, is a form of digitalization that make up the biggest threat to knowledge worker autonomy. Utilizing digital technologies, also cognitive and complex task, or parts of them, is subject to computerization (Ford, 2009; Skidelsky, 2019; McAfee and Brynjolfsson, 2014). In particular, tasks like data gathering and data processing may be automated (Chui, Manyika and Miramadi, 2015). Some claim AI could contribute to liberation of resources and improve decision making, while retaining or increasing the professional autonomy (Dhanrajani, 2018). However, the support AI provides must be understood and interpretable by the knowledge worker. If not, there may be a loss in perceived autonomy (White, 2018).

The expectations about the future of work, is widely discussed. Some studies state that there will be a increased demand for highly educated workers in the future, which must be capable of complex problem solving (Bonekamp and Sure, 2015; Butollo, et al., 2018). Moreover, autonomy is a privilege that knowledge workers increasingly will expect in the future (Morgan, 2015), especially with the millennials entering the labor market demanding flexibility and constant feedback (Cognizant, 2012). These predictions indicated the importance of addressing and understanding "the autonomy paradox". Digitalization will bring changes to the workplace. Still, in what way it will affect jobs, is unclear. For the first time in history, cognitive and non-routine tasks are subject

to automation. Despite the knowledge worker´s demand for autonomy and the benefits autonomy brings, autonomous jobs are under threat. The uncertainty about how digitalization will affect knowledge worker autonomy, is illustrated in "the autonomy paradox". Further, there is no consensus about what an autonomous job is. Weisman (2014) suggests that employees can be allowed autonomy over the following criteria; what they do, how they do it, when they do it, where they do it, and with whom they do it. Seemingly, digitalization could alter all these criterias, both positively and negatively. These relations emphasis the need for further exploration, specifically a deconstruction on extant research.

## 3. Methodology

To advance our understanding regarding the effects of digitalization on knowledge worker autonomy, the present study offers a systematic literature review aided by bibliometric analysis. We conducted a structured literature search in order to identify and select core articles upon which further research on the relation between autonomy and digitalization could be built. These *core articles* were identified by using a combination of bibliometric method and different objective and subjective criteria. Finally, we conducted a content analysis of these core articles, which constitutes the findings of this study.

### 3.1 Structured literature search
In this study we collected the data from ISI Web of Science (WoS), which covers academic research from 1987 until today. By applying WoS's "Topic-search", we matched our phrases with the *titles*, *abstracts*, *author keywords* and *keywords plus*. After experimenting with different search phrases and analyzing the respective results, we decided to combine the phrases (Digi* OR techno*) AND "autonomy". Digi* covers concepts like digitalization, digitization, digital etc., while Techno* covers technology, technological, etc. This combination of phrases resulted in 3961 articles. Confined to the categories Management, Business, Law, Surgery, Automation Control System, Computer Science Information System, Computer Science Artificial Intelligence, and Public Administration, we got 815 results considered applicable for this study.

### 3.2 Bibliometric analysis
"Bibliometrics is a method that includes statistical analysis of published articles and citations therein to measure their impact (Maditati, et al., 2018)." The dataset from Web of Science was exported for further analysis. We utilized VOSviewer to graphically illustrate the dataset. VOSviewer generates a "map" where *clusters* of articles, keyword or authors are differentiated by colors (Figure 2). Each cluster is supposed to have bibliometric similarities, dependent on what method being used. In this study, we applied two methods; Co-Occurrence and Bibliographic Coupling. Co-occurrence is a method that extract keywords that are frequently used, from the articles abstract, title and given keywords. The distance between two keywords indicates how often two keywords are being used together, while the size of each keyword is dependent on how many times the keyword occur (Van Eck and Waltman, 2014). Bibliographic coupling illustrates the relations between articles based on their references (Boyack and Klavans, 2010).

### 3.3 Selection of Core articles
To further analyze our results, we carefully read the abstracts of the articles with more than ten citations, and also articles with autonomy in the title, to cover newly published articles. This resulted in 60 articles we considered interesting. Further, we graphically illustrated the full dataset of 815 articles in VOSviewer, using the bibliographic coupling method. The 60 articles we found earlier, were identified in the map generated by VOSviewer. We analyzed the clusters and links to each document, to gain insight to their bibliometric network. This analysis resulted in 40 articles, subject for careful investigation we further excluded 25 articles that did not suit the purpose of our study. Finally, we carried out a content analysis of 15 core articles, which will serve as the foundation for our discussion and conceptualization.

## 4. Findings

In this section we will first present descriptive findings from our database. Then we discuss the results of the content analysis, which identified three different levels of digitalization; hardware, systems and algorithms.

### 4.1 Descriptive findings
In Figure 1, a bar graph illustrates how the 815 publications are distributed over the last 28 years. By looking at the bar chart, it seems like the topic has been relevant for some time. The increased number of publications

over the last few years might be explained by the rapid technological development during the same period or that the relation between autonomy and digitalization has increased in interest.
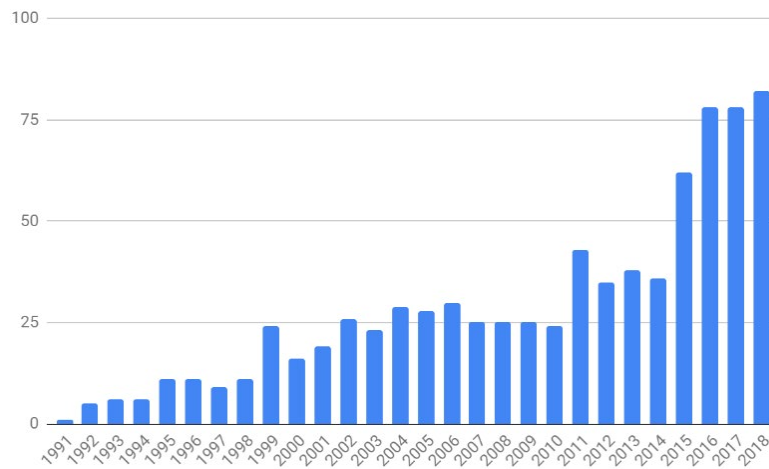


**Figure 1**: Graph illustration of number of publications per publication years (N=815)

Figure 2 illustrates central clusters and articles utilizing the bibliometric coupling method in VOSviewer. We used this as a tool to select our core articles. The clusters are recognizable by different colors and each cluster includes articles which covers the same themes. The green cluster is dominated by articles that discuss the implementation of new technologies and how the user adopt these technologies. Telecommunication, and its effect on workers, are considered in the purple cluster, while the orange cluster covers multinational relations. The pink cluster treats how organizations and occupations are changing and the turquoise cluster have a team-level perspective. Lastly, the black cluster primarily focus on research and development. Our core articles are identified and selected from four of these cluster; the green, purple, black, and pink.
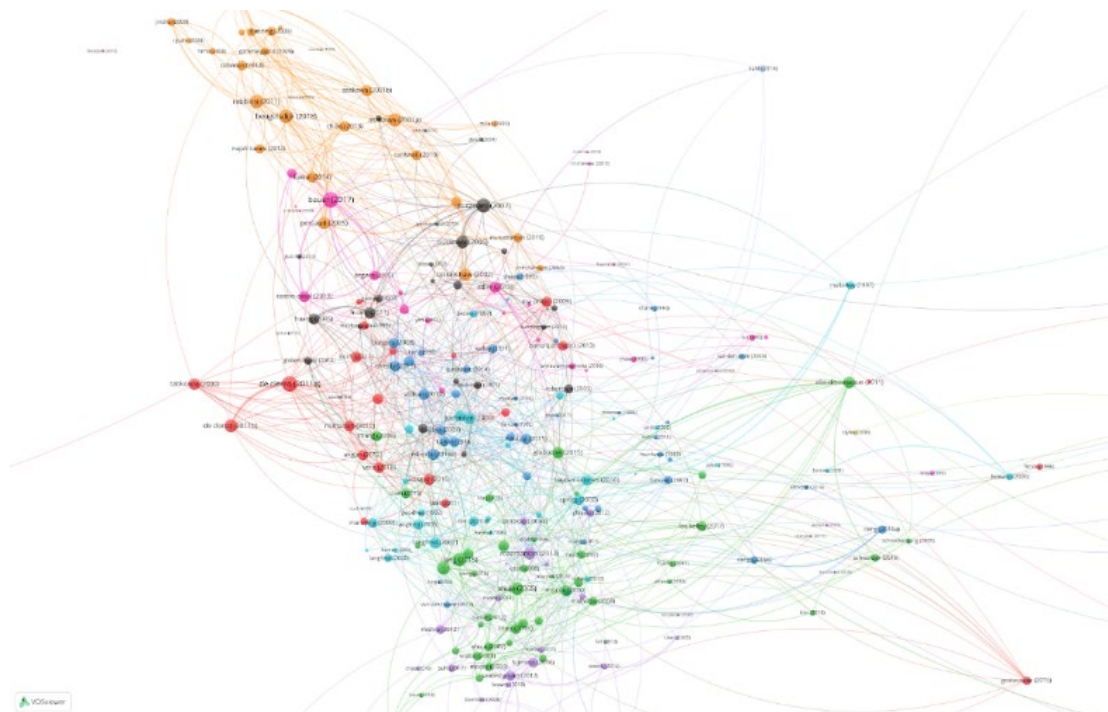


**Figure 2:** Illustration of central clusters

### 4.2 Findings from the content analysis

The content analysis of the 15 identified core articles revealed that prior research addressed autonomy in relation to three very different levels of digital technology: Hardware, systems and algorithms. We present our findings according to these three levels.

#### 4.2.1 Hardware

Researchers have shown interest in explaining how autonomy is affected by technologies that disrupts the traditional nine to five workdays. Hardware, like smartphones and other mobile devices, enables employees to communicate and share information regardless of time and space. We have previously presented that digitalization may lead to increased flexibility and independence (Gerten, et al., 2018; Underthun and Steen, 2018). The content analysis points in the direction that a critical view towards these claims should be considered. Digital tools that enable enhanced communication and information sharing could lead to flexibility and transparency (Bouee, 2015), but also increased connectivity and work-related stress, emerging from being available 24/7. This constitutes the "autonomy paradox" (Mazmanian, et al., 2013; Cavazotte, et al., 2014). Additionally, this technology makes centralized decisions easier (Bloom, et al., 2014), and might facilitate monitoring and increase the need for IT-support (Brey, 1999; Gerten, et al., 2018). How the autonomy paradox is perceived, could depend on individual factors (Bader and Kaiser, 2017). E.g. a graduate will have different needs for flexibility, than a mother with three children. Thus, the perceived threat to autonomy will differ. Table 1 summarize how core articles identify effect of hardware on autonomy.

**Table 1**: Core articles regarding hardware

| Author | Type of technology | Profession | Effect on autonomy |
|---|---|---|---|
| *P. Brey (1999)* | Computer connected to internet (Home office) | Not specified | + Flexibility<br>- Standardization<br>- Need for IT-support<br>- Surveillance |
| *M. Mazmanian, WJ. Orlikowski, J. Yates (2013)* | Blackberry (Mobile email device) | Private equity group, corporate law, venture capital, and investment banking | + Flexibility<br>- Availability |
| *V. Bader, S. Kaiser (2017)* | Blackberry (Mobile email device) | Not specified | + Flexibility<br>- Availability |
| *F. Cavazotte, AH. Lemos, K. Villadsen (2014)* | Smartphones | Law Firm | + Flexibility<br>- Surveillance |

#### 4.2.2 Systems

The next level identified in the content analysis of the 15 core articles was related to IT systems that are integral parts of work practices. Our analysis reveal digital systems, such as ERP or CRM systems, have been widely implemented across businesses and industries. However, digital systems seem to have contradictory effects on knowledge worker autonomy. On the one hand, digital systems could increase autonomy by enhanced information sharing and transparency (Gerten, et al., 2018; Underthun and Steen, 2018). Leaders could also utilize digital systems to empower workers and entrust them with freedom and responsibility (Bouèe, 2018; Bloom, et al., 2014; Tafti, et al., 2007). On the other hand, precise and efficient monitoring and control could override the positive effects (Gerten, et al., 2018; Underthun and Steen, 2018). Tafti, et al. (2007) points out that if the firm aims to empower workers and increase autonomy, the digital systems must support these relations and not the opposite. Further, the content analysis finds that not all workers necessarily are comfortable with responsibility, even with sufficient information (Morris and Venkatesh, 2010). This supports Cognizant´s (2012) claims about the future of work. In this report Cognizant finds that millennials expect frequent feedback and guidance, but still demand autonomy (Morgan, 2015; Cognizant, 2012; Nordenflycht, 2010). This could be an autonomy paradox at another level than what Mazmanian, et. al (2013) presented. We found similar paradoxical relations elsewhere in the literature. Still, monitoring and control seems to be the dominating effects. Project Management Techniques, with the aim to allocate resources to the most profitable research projects, were implemented in a information technology firm (Gleadle, et al,. 2012). This study found that knowledge workers in the R&D department experienced a significant loss in their professional autonomy, resulting in some workers leaving the company, while others engaged in leader positions or found meaning in ongoing projects. Studies

have also covered the implications of standardising medical practise. An example is how standardization of information sharing between departments in a hospital resulted in a shift of autonomy. The medical professional providing information felt limited and less autonomous, while following a "check-list" when sending patient information to another department. The professional receiving the information experienced a boost in autonomy, having received complete information about the patient (Petrakaki and Kornelakis, 2016). Medical professionals expressed significant displeasure after implementing standards regarding operations (Huber and Gärtner, 2018). Especially, the period that was scheduled for the operations, made the professionals feel less autonomous (Huber and Gärtner, 2018). The content analysis reveals how suppliers of digital technology have influence in on the technology use, by designing systems where knowledge workers experience a loss in decision-making power (Schneller and Wilson, 2009) and experienced autonomy. Table 2 summarize how core articles identify effect of systems on autonomy.

**Table 2**: Core articles regarding systems

| Author | Type of technology | Profession | Effect on autonomy |
|---|---|---|---|
| *D. Petrakaki, A. Kornelakis (2016)* | Care record service system | Radiologist, nurses and doctors | + Efficiency<br>+ Information sharing<br>- Standardization |
| *C. Huber, C. Gärtner (2018)* | Hospital information system | Surgeons | +/- Transparency<br>- Standardization |
| *A. Tafti, S. Mithas, M.S. Krishnan (2007)* | Information sharing | Not specified | +Information sharing<br>- Surveillance |
| *S. Rivard, L. Lapointe, A. Kappos (2011)* | Clinical information system | Nurses and doctors | + Liberation of time<br>- medical dominance<br>- Standardization |
| *ES. Schneller, NA. Wilson (2009)* | Not specified | Surgeon | - Medical dominance<br>- Surveillance |
| *P. Gleadle, D. Hodgson, J. Storey (2012)* | Project management technique | R&D | - Decision power<br>- Monitoring |
| *N. Bloom, L. Garicano, R. Sadun, J. Van Reenen (2014)* | ERP/Intranet | Factory managers | + Information sharing<br>+ Decision power<br>- Decision power |
| *Z. Walter, MS. Lopez (2008)* | Electronic medical record | Medical professional | + Information sharing |
| *MG. Morris, V. Venkatesh (2010)* | ERP-system | Not specified | +/- Decision power |

### 4.2.3 Algorithms

Two of the most prominent technologies the last few years is AI and Big Data (Shrouf, et al., 2014). In the literature, there is no consensus on how work will be affected by the digitalization. While some claim that digital technologies primarily will affect low-skilled workers and that knowledge work is too specialized to automate (Frey and Osborne, 2013; Christensen, et al., 2013; Løwendahl, 2005), others argue that also these workers are subject for automation (McAfee and Brynjolfsson 2014; Ford 2009). The content analysis indicates that both AI and Big Date could affect knowledge workers. Increased availability of medical data made it possible for algorithms to make medical suggestions. Physicians experienced this technology as a threat to their professional autonomy, and a loss in social status. (Walter and Lopez, 2008; Ezmaeilzadeh, et al., 2015). McAfee and Brynjolfsson (2014) highlights that some tasks knowledge workers perform have the potential to be automated.

Dhanrajani (2018) claims that AI could improve decision making, while retaining or increasing autonomy by liberating time and resources. White (2018) emphasize the importance of separating between AI for decision making and AI for decision support. The content analysis suggests that, even while utilizing AI as support, knowledge workers showed resistance, as they experienced a loss in medical dominance, which in turn weakened their social status and autonomy (Adler and Kwon, 2012; Eaton-Wally and Lowe, 2017; Nordenflycht, 2010; Rivard, et al., 2011; Walter and Lopez, 2008). To limit the resistance towards implementations of AI, White (2018) points out that the decisions being made by AI must be understood and interpretable by the knowledge workers. We find support for these claims in the content analysis. Esmaeilzadeh et al. (2015) find that the knowledge worker´s IT-competence and their attitude towards knowledge sharing could reduce their perceived threat to autonomy. We also found that where medical professionals participated in the selection of technology, the resistant towards the technology decreased (Rivard et al., 2011). The findings indicate that the knowledge worker's perceived autonomy, regarding algorithms, may be influenced by several factors. Among these are social status, decision power, IT-competence, and the attitude towards knowledge sharing central. Table 3 summarize how core articles identify effect of algorithms on autonomy.

**Table 3**: Core articles regarding algorithms

| Author | Type of technology | Profession | Effect on autonomy |
|---|---|---|---|
| *Z. Walter, MS. Lopez (2008)* | Clinical decision support system | Medical professional | - Decision power<br>- Social status |
| *P. Esmaeilzadeh, M. Sambasivan, N. Kumar, H. Nezakati (2015)* | Clinical decision support system | Medical professional | -Decision power<br>- Social status |
| *PS. Adler, SW. Kwon (2012)* | Clinical guidelines | Medical professional | +/- Decision power<br>- Standardization |

## 5. Discussion of results

In this study, we have identified three levels of digitalization, which affect knowledge worker autonomy differently. The aim of this section is to contribute with a framework (figure 3), including unique considerations, within the levels of digitalization. Leaders can utilize this framework to reduce knowledge workers resistance to digital change and gain insight to "The autonomy paradox".
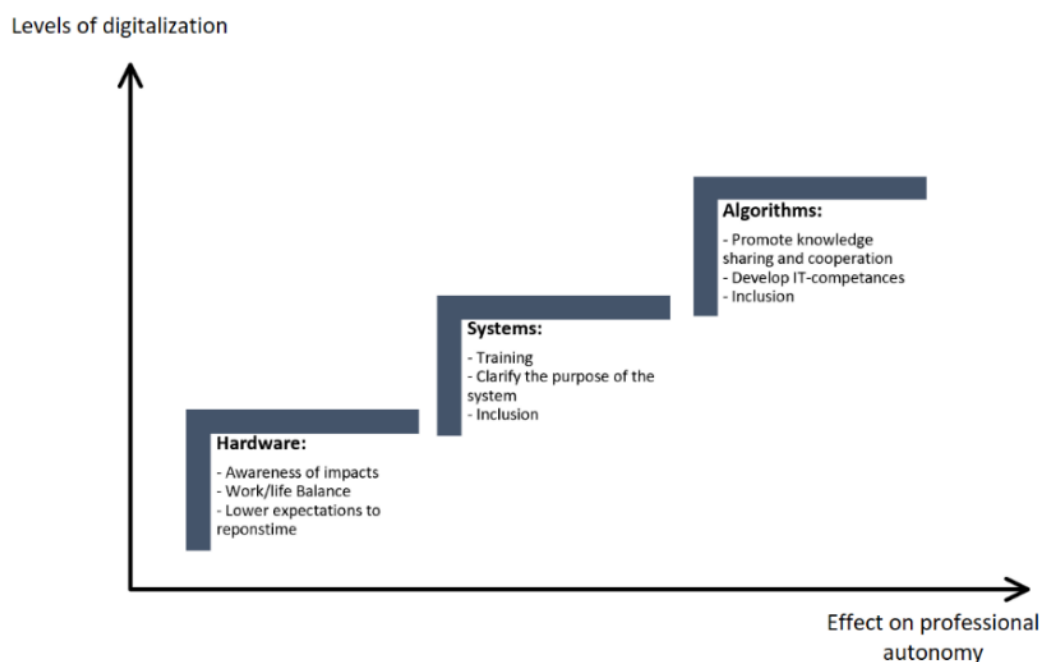


**Figure 3**: The effect of different digitalization level on professional autonomy

### 5.1 Hardware

On the first level, the effects on autonomy is quite predictable. Table 1 clarifies that the same effects on autonomy occur throughout the literature. We have also emphasized that perceived autonomy can differ between employees. Further, we notice that both leaders and employees are well aware of the negative effects digital communication tools may have on professional autonomy. The content analysis displayed few instances where knowledge workers resisted the use of mobile devices, even though the employees reports increased workload and stress. It is desirable to retain the positive effects displayed in Table 1, while reducing the negative. A factor responsible for increased workload and stress, is the expected availability. Thus, when implementing digital communication technologies, we recommend change agents to inform the employees about the downside related to unhealthy use, and create a culture where employees are given respite outside working hours.

### 5.2 Systems

The second level include several factors that affect the perceived threat to professional autonomy. Systems are, generally, being implemented with the aim to improve the efficiency and transparency. Even though control and monitoring are factors that reduced the worker autonomy, our findings suggest that increased transparency and empowerment of employees, often will increase the autonomy. As displayed in Table 2, standardization is considered to have a negative impact on professional autonomy. We discovered instances where knowledge workers expressed resistance to the newly implemented systems, due to a reduction in professional autonomy.

Factors that affect the knowledge workers perceived threat to autonomy, should be emphasized by change agents facing implementation of digital systems. By including the employees in the implementation process, clarify the purpose of the system, and provide a thorough training, the expected perceived threat to autonomy may be reduced.

### 5.3 Algorithms

The third level includes technologies that constitutes the biggest threat to knowledge worker autonomy. In the content analysis, implementations of algorithms aim to improve or simplify decision-making. Consequently, also non-professionals are able to make advance decisions, previously made by professionals, which reduces the need for expertise and weakens knowledge worker's decision power. Table 3 illustrates that loss of decision power has the biggest impact on knowledge worker autonomy, within this level. The content analysis indicates that knowledge workers experience a loss in social status when they, to a lesser extent, are able to exercise expertise and hold esoteric knowledge. We consider this to be a central reason why management meet resistance, when implementing technologies within this level. Change agents are encouraged to create an organization culture where knowledge sharing, collaboration, and helpfulness is promoted, with the purpose of curbing professionals' need for esoteric knowledge. We have previously discussed that employees must be able to understand and interpret decisions being made by algorithms. Change agents can influence this by including the employees in the implementation and make sure they possess the skills necessary to understand the technology.

## 6. Conclusion

The aim of this study was to investigate how digitalization affected knowledge worker autonomy through a rigours analysis of extant punished research. The understanding of how the knowledge worker's professional autonomy are affected by digitalization has been diffuse and paradoxical. Our findings confirms that digitalization affect knowledge worker autonomy in different ways, and extends current understanding by identifying three levels of digitalization, which have different impact on autonomy. Further, we have found that each level of digitalization could affect Weisman's (2014) five criteria differently. If leaders aim to utilize digital tools to fulfil these criteria, we argue that the considerations presented in our framework must be taken into account. The content analysis indicates that autonomy is hard to measure, thus interpersonal relations between leaders and employees are crucial to reduce the resistance to change and successfully implement new technologies. Based on our study, we can also suggest make some directions for further research. The content analysis included limited empirical studies covering the use of algorithms and only one industry were represented. The use of algorithms on the workplace are new, which might justify the lack of empirical studies.

Thus, we consider it interesting to make further studies about the effects algorithms have on knowledge intensive work. Our study also have limitations. To achieve a greater insight and foundation for our study, we could have included more databases and read more articles. Further, several of our sample criteria were

subjective, like the evaluation of articles based on abstract and title, meaning we could have excluded relevant articles. We filtered our database by choosing categories subjectively and only read the titles of the articles with ten or more citations. By using other sample methods, we could have taken into account more recently published articles and a broader scope of categories.

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