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Manufacturing Revolution Boosts People Issues: The Evolutionary Need for ‘Human-Automation Resource Management’ in Smart Factories

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Driven by significant innovations in manufacturing on the edge of a ‘second machine age’, automation will play a pivotal role in turning the world of work upside down. Digitized manufacturing is fundamentally changing relations between human and machine. The expected symbiosis has not yet been systematically organized, since human resource management has widely ignored the topic of automation. If HRM fails to answer the final call, it will lose its influence in smart factories, ultimately being replaced by other functions. Our theoretically derived concept of human-automation resource management (HARM) discloses a possible way out by specifically tackling the conjunction between humans and machines. We will sketch HARM as the combination of HRM and automation management and, therefore, as the next evolutionary step in the advancement of HRM. After supporting the strategic integration by means of its synergistic benefits, we will determine the tasks HARM is expected to fulfill at the automation-people-nexus.

Keywords: human resource management; automation; future of industrial labor; manufacturing; smart companies

Introduction: people and the automation of manufacturing – A mutual exclusion?

Imagine the smart factory of the future: completely modularized manufacturing processes, monitored, largely data-optimized, with blockchain-based payment flows, and steered by decentralized cyber-physical systems that generate as many autonomous real-time decisions as possible. People from the core workforce as well as from the working cloud create the computerization infrastructure and provide for higher-order decisions, conflict solution, and meaning in terms of business model and value creation. Many people-related challenges arise: from factory layouts and manufacturing interoperability to skill shifts, life-long learning, corporate cultural sustainability, work ethics, etc. Will the interests of robots and humans be played off against each other? Who

decides on that? Who can, who will take the lead in transforming smart factories?

Ever since our ancestors crafted primitive tools out of stone, innovations in manufacturing have continuously led to changes in the working world, and to work itself. Today, the innovative contribution of technology to manufacturing lies within its automation (Chryssolouris *et al.*, 2008), applying robots (Engelberger, 2012), sensor systems (Meijer *et al.*, 2014), and full software support (Xu, 2012) to advanced production processes (Zhong *et al.*, 2013), material handling (Wang and Shih, 2016), payment transactions (Dieterich *et al.*, 2017), and quality control (Ghosh, 2014).

While automation optimizes production processes and allows for transformation towards a knowledge-based society with high energy efficiency, the collateral damage of collaborating robots is the potential destruction of jobs (Worstell, 2013). Similar to the era of industrialization of the 18th and 19th century, the definition of work has been changing and will continue to change rapidly again in the 21st century. Human-robot-teamwork (Nourbakhsh *et al.*, 2005) brings about an increasing determinability of

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location, flexibility, and efficiency of work (Angerer *et al.*, 2012). In today's working world free of boundaries and limits (Ohmae, 1990), with the human brain remaining the main source of innovativeness (Brynjolfsson and McAfee, 2012), automation leads to a digitization-oriented shift in the needs of employers (Levy and Murnane, 2012; Collin and Palier, 2015) and thus to a growing imbalance in the supply and demand of required qualifications (Cappelli, 2012). Researchers paint the picture of a race of humans against machines (Brynjolfsson and McAfee, 2011). Sennett (2005, p. 83) even describes working people as afflicted by a 'specter of uselessness'. Examples such as Foxconn replacing workers with one million robots (Ackerman, 2011) or Watson, IBM's artificially intelligent computer program winning at Jeopardy, strengthen this belief. Defeated by Watson, the contestant Ken Jennings stated: 'I, for one, welcome our new computer overlords' (Markoff, 2011).

The prevalent discourse structure on the future relationship between humans and robots resembles an either/or discussion (PwC, 2017; Elliott, 2018): when one rises, the other one falls. The protagonists of this either/or view adduce comprehensible reasons: in favor of the humans, researchers invoke that only real people can be creative, judging, socially empathetic, and situationally valuable (e.g., McAfee, 2014; Wu, 2015; Pistrui, 2018), and they refer to the recent failure of Tesla's fully-automated not at all 'smart' factory (Edwards and Edwards, 2018). In favor of the robots, researchers argue that only machines can work constantly, error-free, technologically sustainably, and cost-efficiently (e.g., Deloitte, 2015; Wingfield, 2017).

Reviewing this discussion, its underlying problem cannot be overseen: it is a play-off against each other, leading to a rather destructive win-lose result or even lose-lose result of the inherent conflict of distribution of work (McKinsey Global Institute, 2017). As it is well-known from negotiation methods such as principled negotiation (Fisher and Ury, 1981), striving for a win-win-result allows for the combination of the qualities of each side. This gives rise to a synergistic view in terms of a symbiotic both/and relationship of working humans and working robots (e.g., Flemming, 2019), which is still a neglected topic in research, especially lacking a theoretical framework.

The research gap consists of the specification of the automation road ahead for businesses in four exploratory fields: (a) the business function/s that organize/s the concomitant transformation; (b) the existence of synergies between working humans and working robots as part of the changing automation reality and of the automation narrative; (c) the task areas for the exploitation of synergies on condition of minimal collateral damages; and (d) the ways to balance the cost of renewal and profitability.

However, the literature on the humans' way of handling automated manufacturing from a human perspective is scarce and reflect a distant, apprehensive position: 'Today, people treat most robots in the workplace like wild lions: caged and approached only by trained staff' (, p. 15). Only a few papers focus on people's reaction to robot-made decisions (Borenstein and Arkin, 2016; Geiskkovitch *et al.*, 2016), the social and emotional perceptions (Sauppé and Mutlu, 2015), the people's employability (Davenport and Kirby, 2015), and the competences required to deal with this change (Bremer, 2015; Gallina *et al.*, 2015). They all are rather selective and concentrate on specific points of interest, but without bringing together the theoretical foundation and conceptual clarification of how, in the near future, humans and robots will presumably be working as a team (Beer *et al.*, 2014). Therefore, it will be essential to shape the human role within the automated world before it becomes obsolete.

This paper contributes to the existing but scarce literature in both theory and practice. Up to now, general discourse sees automation as a force that will lead to significant turmoil concerning labor, especially as it is driven by technology rather than by the humans. At variance with those opinions, this paper underlines the synergistic potential of combining humans and robots. This understanding signifies the theoretical anchoring in the capabilities-oriented strategic management perspective with the focus on the resource-based view (Barney, 1991). The management of a business utilizes any resources to achieve a sustainable competitive advantage. This competitive advantage is usually based on the combination of valuable, rare, imperfectly imitable, and non-substitutable internal resources (Barney, 1991) and capabilities, best developed as first mover on the market. As knowledge about technological innovations and improvements is quickly circulated, the resource focus nowadays incorporates these accelerating dynamics. Consequently, Helfat and Peteraf (2003) refine the strategic management of organizational resources and capabilities towards the 'dynamic' resource-based view. This paper, therefore, evaluates the strategic alternatives of dynamically managing categorically different organizational resources in future labor regimes.

Furthermore, we aim at deepening the debate in which the human perspective will retain importance in this context. The human factor will remain the crucial source for creating competitive advantages for a business and for ensuring its social harmony. It is not by chance that human resource management (HRM) has evolved as a business function to concern itself with issues such as work ethics (Sloan and Gavin, 2010), sustainability (Jabbour and Santos, 2008), and responsibility (Shen, 2011), and, therefore, is predestined to answer crucial

questions regarding the future of labor. But as to be shown below, HRM has thus far failed to evolve as a driver for the definition of a future automation-people-nexus. This paper's objective is to outline a fruitful integration of the resource-related management of humans with automation. Our theoretical foundation will substantiate the evolutionary need for functional integration with HRM to include automation, perceive it as a coequal work-related management challenge in future manufacturing companies, and to consequentially bridge the gap between humans and automated systems. As a result, HRM takes the road to being transformed into the integrated corporate function of human-automation resource management (HARM). We will conceptually design the HARM function including its synergies and tasks, thus discussing its functional significance within smart factories.

Outdated: separate business functions as serving key players

Automation resource management

In the history of manufacturing automation, technological progress transformed the social reality of production systems, with the underlying explanation following the theory of technological determinism (e.g., Blauner, 1964; Smith and Marx, 1994) according to which the cause of change is technology, and its effect is social adaptation. Technological determinism identifies technology as the decisive force behind social change, the key mover in history (Kunz, 2006), and Postman (1992, p. 7) states 'The uses made of technology are largely determined by the structure of the technology itself, that is, that its functions follow from its form'. Karl Marx who recognized 'The handmill gives you society with the feudal lord; the steam-mill, society with the industrial capitalist' (Marx, 1971, p.109) already criticized this deterministic view and broadened it towards social productive forces (MacKenzie, 1984). This was seized by industrial sociology, pointing out that any technological system is inevitably shaped and co-constructed by society (e.g., MacKenzie and Wajzman, 1999; Degele, 2002). Nowadays, digitization could once more trigger a change: societal influence is still formative but diminishes with increasing autonomy of applied digital technology and the immersive dependence of the business model on interconnected value chains – a phenomenon that is already coined 'technological momentum' (Hughes, 1994) in times of early computerization. Current developments in self-driving cars, unsupervised algorithms, and artificial intelligence prompt that technology may become a fully automated actor and at the same time an integral player in shaping

the societal consequences. In line with technological determinism, the notion of potentially no longer requiring human interaction at all is rooted in the actor-network-theory, as highlighted by the basic statement that there are 'only actors – some human, some non-human, some skilled, some unskilled – that exchange properties' (Latour, 1992, p. 236).

Automation represents one of the most influential transformations of manufacturing. Derived from the Greek term *ατόματος* (automatos: acting of one's own will, of oneself), associated expectations concern the increase of productivity, quality, process reliability, and labor cost-effectiveness (Mital and Pennathur, 2004; Wunsch *et al.*, 2010; Baily and Bosworth, 2014). While automation has led to more humane jobs (Klotz, 2012) by superseding monotonous or physically exhausting and dangerous work (Brown, 1996), it has nonetheless gained the reputation of being a job killer. Especially science-fiction depicts dystopian futures that often contain sinister automation scenarios – such as 'The Matrix' from 1999. The factual history of automation paints a different picture. Already the weaving machines marking the beginning of automation at the end of the 18th century, created more new jobs at that time than killing old ones. In spite of 'technological unemployment' (Keynes, 1963), that is, that some skills became obsolete during industrialization, it is a popular misconception held by workers, unions, and economists that any task that can be performed more effectively by a machine, will inevitably be automated (Frey and Osborne, 2013). This misconception, though undoubtedly containing some truth in terms of structural efficiency enhancement, leaves out the free entrepreneurial decisions concerning work design as well as the necessity of social legitimacy. Researchers expect automation to have a neutral or even positive impact on the labor market (Miller and Atkinson, 2013; BAIN, 2018; World Economic Forum, 2018), with the collaboration of humans and machines to be far superior to human–human or machine–machine (Kelly, 2014; Ford, 2015).

In line with Moore's Law (Moore, 1965), automation seems to be growing exponentially. In our present 'second machine age' (Brynjolfsson and McAfee, 2014), programmatic concepts such as computer-integrated manufacturing (CIM) from the 1970s (Harrington, 1973), 'Industry 4.0', big data, and RFID aim at the interconnection and autonomous interaction of machines. Those concepts have become an obligatory part of 'smart' factory (Radziwon *et al.*, 2014) design. Already a reality (Zuehlke, 2008), smart factories are self-evidently shaping the factory landscape in several countries, for example, in the US (Hessman, 2013), Germany (Bryant, 2014), the Netherlands (Smart Industry, 2014), China (Malkovich, 2015), and South Korea (Ji-Yoon, 2015). They differ fundamentally from classical factories. Machines and

related manufacturing processes have become more and more 'intelligent' or 'smart' (Batchelor and Waltz, 2012) and have begun to open the 'lion cage' (Dietsch, 2010) in the sense that, in certain fields, humans and machines are already working together in symbiosis (Mertens, 2015) or that smart factories no longer require any human labor at all (Alessi and Gummer, 2014). Automation-related changes are induced by information systems. They are located at the 'confluence of people, organizations, and technology' (Hevner *et al.*, 2004, p. 77) which enables them to communicate and interact (Goodhue and Thompson, 1995). Information distribution and data processing are essential for the management of automation, which is still on the verge of increasing in intricacy and complexity. Interestingly, this process itself cannot be automated or outsourced to machines – or, if so, only to a certain degree.

We label this process of organizing and managing automation 'automation resource management' (ARM). ARM is concerned with overseeing, designing, coordinating, and controlling machines and adapting them to the given production systems and corporate business processes. In contrast to traditional operation management, ARM will be essential for every type of organization that depends on information system-driven machines (e.g., computer-aided engineering, CNC systems, 3-D printer, etc.) and will not be limited to the manufacturing industry. Obviously, ARM does not cover the human side of automation, so that it would bear an inherent deficit if put into responsibility as separate silo function. ARM may be fitting for certain operational aspects of the automation, but in a strategic management approach it is barely sufficient.

Human resource management

People issues tend to follow the narrative of social determinism (Green, 2001) with social shaping (Williams and Edge, 1996) and social construction of technology (Bijker *et al.*, 1987; Winner, 1993). Related theories identify people and their corresponding societal needs as drivers of technological change. Society or social groups attribute meaning to technology and its usage. For this reason, 'technology is a very human activity' (Kranzberg, 1986, p. 557), influenced by a variety of social factors such as history, economics, and ideology (Giddings, 2006). Following upon this idea, technology has been developed to saturate societies' needs, thus overcoming human limitations (Solus, 2012).

Human Resource Management (HRM) tackles the broad range of tasks and problems concerning humans within an organization (e.g., Cascio, 2012; Dessler, 2013). In recent years, information technology and information systems have infiltrated numerous employee-related as well as leadership-related processes.

Electronic HRM (e-HRM) and Human Resources Information Systems (HRIS) (Lengnick-Hall and Moritz, 2003; Strohmeier, 2007; Waddill and Marquardt, 2011) reflect the technical digitization of HRM work. Technological progress has concurrently brought along an increase in atypical employment (Bosch, 2004) and labor displacement right up to cloud work (Ruggieri *et al.*, 2016) as well as unemployment, which also needs to be dealt with by HRM. Businesses are trying to become more flexible and adaptable to change by reflecting the supporting role of HRM (Alagaraja, 2013; McDermott *et al.*, 2015) – and not only with regards to the management of IT personnel (Kaplan and Lerouge, 2007).

One of the recent foci of HRM lies in the employability of the workforce (McQuaid and Lindsay, 2005; Clarke, 2008; de Lange *et al.*, 2015): modern HRM tries to empower employees to achieve or retain individual qualifications and knowledge-related preconditions for their career or to find adequate employment in the given circumstances. While updated knowledge has grown to be the most important factor for individual employability, technological dynamics are on the edge of rendering updated knowledge obsolete (Majchrzak *et al.*, 2013). Companies are trying to overcome this inherent discrepancy by means of training and development in order to counteract the erosion of knowledge (Sung and Choi, 2014).

Particularly focused on automation, human resource development is compelled to match its strategies with the research & development department, which has become a stakeholder of increasing importance to HRM. Especially in the context of smart manufacturing, HRM is facing a potentially dire development. Due to digitization, many work-related processes are to be automated, rendering HR less relevant. On top of the common practice of outsourcing of HR, the HR department in manufacturing companies is sometimes even completely entirely outsourced (Weber and Feintzeig, 2014). HR departments as traditionally separate business functions are seen as being at a breaking point (Heneman, 2013): they can either serve as a lobby for the 'the human role' as part of this technological world of automation, digitization, and big data (e.g., Scholz, 2017), or become obsolete as something to be replaced by those functions that shape automation via IT and technology. Eroding and even erasing HRM could cause people to fall behind as well. This could show dire consequences as the core functionality of HRM remains essential while dealing with those people issues which are boosted by the revolution of smart factories. Therefore, functional integration of HRM and automation is an evolutionary matter of survival for people issues in cyber-physical systems.

Theoretical foundation of the integrated 'human-automation resource management' function

The practice of analyzing the effects of automation on human resource management and vice versa is rooted in technology studies (Quan-Haase, 2013). A distinct theory to describe the tangled interaction between technology and humans, however, has yet to be composed (MacKenzie and Wajcman, 1999). Consequently, in order to achieve a better understanding of the interaction of humans and automated technology in smart factories, we require organizational theories to grasp this modern organizational phenomenon. What are the theoretical constituents for the conceptional integration, both in regard to the strategic integration of ARM and HRM towards HARM, and in regard to the operational linkage? And what does theory contribute to the question of social acceptance of this emerging fundamentally changed social system reality? In the following, the strategic anchoring focuses on strategic organizational sense-making, the operational anchoring relies on transaction cost economics, and the social acceptance is linked with new institutionalism.

The strategic integration of the up-to now separated functions is required in order to challenge the required transformation in the work environment. Automation will change the way how people will work and which role these people will play in smart factories. Consequently, people will have to understand the necessity of these changes. It must become apparent to anybody within the organization, that it makes sense to automate and, by that, link the HRM function with the ARM function. The theory of organizational sense-making (e.g., Weick, 1995) is tackling this question of how to deal with such a situation by addressing the way people attribute individual as well as collective meaning to their experience, therefore, reducing ambiguity in mutual communication. This theory is especially relevant for the employee perspective from within an organization as it affects the extent to which structural changes within an organization are perceived as rational choices (Schoemaker, 1993). Concretely, pointing out the positive effects of an ongoing automation and the consequential strategic integration of ARM and HRM on the value model of the business strategy, can be used as a way to convince the workforce to accept these changes (Jones *et al.*, 2005) as well as to commit themselves individually (Herscovitch and Meyer, 2002). This leads to the chain of reasoning in which the assumption of the inevitability of the dynamic resource-based view in today's business world, in particular in smart factories, mandatorily means the necessity of more dynamic resource reconfigurations (Teece *et al.*, 1997). The more categorically diverse resources are available, the more effective the accelerating

resource reconfiguration will become. The resulting competitive advantages will be more sustainable since automation-related advantages are fairly quickly imitable, but uniquely combined with human resources, they are not. Additionally, this requires to frame the automation narrative as a credible success story with reasonable, realistic milestones for performance progress. In the course of a sense-making process, people make use of several aspects that lead to a changed interpretation of reality (Weick, 1995): the collective creation of a joint identity as actors, an ongoing process of retrospection and enactment in order to build a new narration on real developments, and a process of shared acceptance of plausible explanatory patterns. The goal is to change the mindset into the idea that collaboration, 'if we handle it wisely, [...] can bring immense benefits' (McCorduck, 2015, p. 51). This organizational sense-making goes beyond the operational implementation of automation by highlighting the strategic importance.

From the operational perspective, it is important that the effectiveness expectations are met, that is, that the integration resulting in a single HARM function will turn out to be profitable for the organization. It is necessary to be capable of comparing the increase in efficiency created by integrating human and automation into one distinct function. The transaction cost economics (Williamson, 1981) seem an appropriate approach to tackle this concern. Although bearing in mind that the principal-agent-relationship among humans and robots is widely unpredictable and dynamically changing, still, in the transaction cost view, functional integration is profitable (Silverman, 1999) due to several aspects: first, transaction costs for the organization are declining with an increase in standardization. The related standards developed for a smart manufacturing business utilize the potential of humans as well as that of automation (similar to human-computer-interaction, see Dix, 2009). They are solidified by the constant repetition of processes, drawing a transaction cost profit from a higher frequency of similar coordination tasks (Jones and Hill, 1988). Second, resources that had been untapped before are potentially utilized in new and converted ways: automatic units and robots will possess an abundance of sensors that track a variety of conditions and influences. These sensors track the environment and, along the way, humans as well, transferring them into one single and transaction cost-effective steering logic. The better the robots and humans 'know' each other in advance, the less are the hidden characteristics, the quality uncertainties, and in the end the adverse selection. Third, the minimization of risks, which is to be achieved by integrating both functions into one, leads to the reduction of transaction costs related to uncertainty avoidance (Sutcliffe and Zaheer, 1988). Even though human-robot-collaboration appears to increase complexity at first glance, humans and robots will

eventually learn from each other (Sklar *et al.*, 1998; Ikemoto *et al.*, 2012), and seeing through some of the hidden intentions will consequently reduce potential risks and therefore transaction costs (Chiles and McMackin, 1996). Fourth, the reduction of information asymmetries (Jensen and Meckling, 1976; Balakrishnan and Koza, 1993) has to be considered. Managing humans and robots separately would be inefficient due to information asymmetry with each of them only having limited information at their disposal, resulting in higher agency costs, while integrating both functions would reduce said asymmetry by uncovering some of the hidden actions such as shirking.

In order to address social acceptance (Sagie *et al.*, 1990) of such an emerging social system reality, a discussion about its legitimacy (Suchman, 1995) is necessary. Specifying the question of legitimacy that is part of the new institutionalism (DiMaggio and Powell, 1983), means to ask why it is justifiable that human and automation are unified into one distinct HARM function, especially as this may, supposedly, lead to a loss of jobs. Assessing this legitimacy debate from a meta-level, the tone of the discussion is shifting dramatically in comparison to former times. People no longer only talk about the fight of ‘us against them’ – as it had archetypically been propagated by the Luddites, an anti-technological-progress movement of the early 19th century – even though today’s discussion often takes place in a populist fashion, polarizing the ‘race against the machine’ (Brynjolfsson and McAfee, 2011). Meanwhile, people’s more positive attitudes towards robots, viewing them as team-members, assistants, or colleagues (Mutlu and Forlizzi, 2008), gives robots a new quality of legitimacy. This is especially the case due to robots’ ability to communicate, and their growing symbiotic autonomy (Rosenthal *et al.*, 2012) in terms of multifunctionality that allows modern smart factories to produce many parts needed for their products on their own. Furthermore, botsourcing (Gore, 2013; Waytz and Norton, 2014) reduces the need for outsourcing to low-cost countries. There is an obvious potential that automation leads to a benefit for the employees as well, be it the idea that people no longer have to lift heavy items or that people can work with the robots even better together in a team. Highlighting the benefit from the symbiosis will lead to a basic change in social norms, driving normative isomorphic change, as well as the mimetic isomorphism as the tendency of organizations to imitate expectably beneficial structures (DiMaggio and Powell, 1983), and in the end to an increase in legitimacy.

All three theories fill the theoretical void of understanding and integrating the originally separated HRM and ARM functions, and theory-driven highlight the importance as well as the advantages of such integration.

Conceptual integration: human-automation resource management

Strategic sense: synergy

Technological determinism and social determinism ascribe a strong cause and effect logic to the relationship between technology and society. Indeed, the two aspects are not isolated from each other but have shaped each other mutually (Quan-Haase, 2013). In the sense of duality, technology influences society and is influenced by society (MacKenzie and Wajcman, 1999). Both are strongly intertwined and ‘both society and technology [...] are made out of the same “stuff”: networks linking human beings and non-human entities’ (Mackenzie and Wajcman, 1999, p. 24). They are relational to one another as ‘equal’ objects (Bryant, 2011). For that reason, ‘we are no longer looking at just a “technology” and its “users” but the event of their relationships, of their reciprocal configuration’ (Giddings, 2006, p. 160). However, it is crucial to balance to these relations and establish a conjoint system of social and technological influences. The goal of such a system is to sustain the delicate socio-technological balance (Solus, 2012).

Achieving synergy sounds promising, but in order to gain a realistic picture, it helps to review the existing synergetic interactions between HRM and ARM. One root emerged as the concept of e-HRM. In this framework, information technology was designated to improve the work of HR, however today, IT predominantly drives HR (Ruël and van der Kaap, 2012), and has led to standardization (Voermans and van Veldhoven, 2007) or to outsourcing of the HR function (Farndale *et al.*, 2009). Although e-HRM is not entirely linked to automation, it marks a significant shift of sense-making of the HR function from strategic to operative. Similar developments were observed in the computer-integrated flexible manufacturing systems which were first discussed within strategic HRM (Snell and Dean, 1992), but today are integral parts of operational HR planning (Novas and Henning, 2014). Cyber-physical systems, Industry 4.0, and man-machine interaction are currently researched in the field of strategic industrial & labor relations (Spath *et al.*, 2013) and might result in the organization of operative work process relationship that is up to now covered by ARM. Therefore, HARM makes sense in terms of synergy.

One crucial change currently shaping the future relationship between human and robots relate to their communication patterns. In the past, humans have given directives to machines. The general issues were human-human-interaction and human-machine-interaction. For this reason, HRM and ARM effectively worked in separation with real interaction between humans and machines at a minimum. In recent years, however,

machines have been taught to talk to each other, which is known as machine-machine-interaction (Ford, 2009), and, more importantly, to talk back to humans. Machines can ask for help, and are now part of teams (Rosenthal *et al.*, 2012). Figure 1 depicts the shift between these two worlds of communication, revealing the need for new accommodation tools. Something that intensifies this new situation is the machines' capability of learning with or without human help. Training and development are no longer reserved for human employees but are also required for machines. The modern non-human-centric communication network implies that machines can teach humans just like humans can teach machines. Evidently, the traditional and well-established ARM and HRM methods are limited to a certain point of assumed separation while both worlds require a merged function that unlocks the synergistic potentials.

This leads to the discussion of 'symbiosis versus synergy' (Stein, 2014). Symbiosis had been the leading paradigm in creating value from the interdependence of people and computers, as Licklider's (1960) term 'man-computer symbiosis' emphasizes. According to this paradigm of mutualism, 'human operators are responsible mainly for functions that proved infeasible to automate' (Licklider, 1960, p. 4), which leads to a symbiotic co-existence with a clear division of tasks. HARM, however, exceeds the idea of mere symbiosis: the resource management of two different areas is merged into one integrated resource management, causing additional value to emerge from the 'collaborative advantage' (Huxham and Macdonald, 1992, p. 51), learning effects, the creation of additional knowledge, economies of scope, and the mutual compensation of the other's weaknesses (Figure 2).

Procedurally, it is necessary to recognize demands from both ARM and HRM that have to be accepted simultaneously in the future of an integrated HARM function. A merging process based on the least common denominator has to be avoided on all accounts. Regardless of their former preferences, the two partners will have to pursue the same organizational goals and will have to share their resources, especially information. Information systems will obviously be the major enabler of the HARM merger by improving joint communication and establishing a shared language. Moreover, it is necessary to formulate a joint vision, coordinate strategies, share

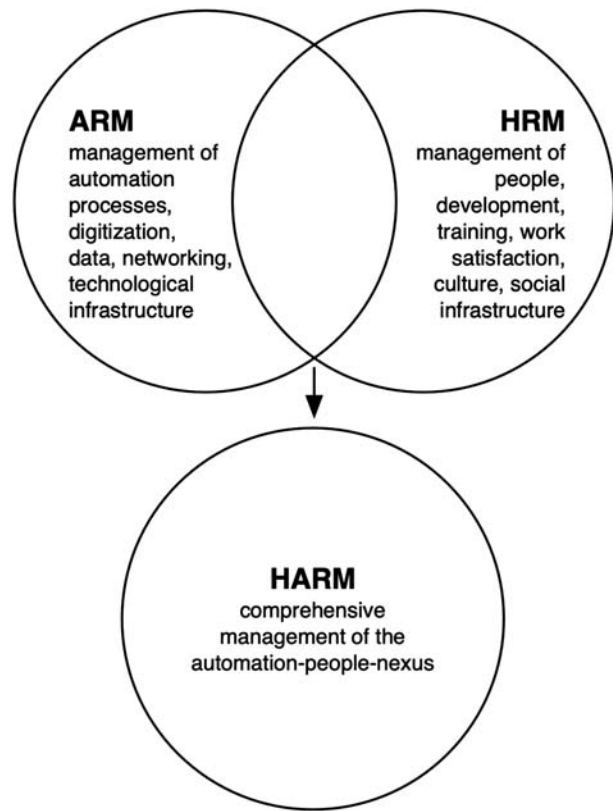


Figure 2 Synergistic logic of the merger of ARM and HRM to HARM

knowledge, use material resources together, concentrate bargaining power, consolidate the governance of risks, and finally increase the value creation (Tantalo and Priem, 2014). The 'natural enemies' of this type of synergy are a culture of secretiveness, inappropriate incentive structures, mistrust, dominant employees, and an underdeveloped performance orientation (Gold and Campbell, 2000).

Because functional integration is a change process which involves the risk of job cuts, emotional resistance (Ford *et al.*, 2008) is likely to emerge and has to be dealt with by means of a mutual learning process (Dass and Parker, 1999). At the same time, acceptance of the new HARM function has to be created by overcoming former rivalries between ARM and HRM. Integrative and synergistic HARM work has to be practiced especially due to different cultural roots in problem solving. In its 'competitive acceptance model' (Scholz and Stein, 2013), intercultural management shows how to unveil

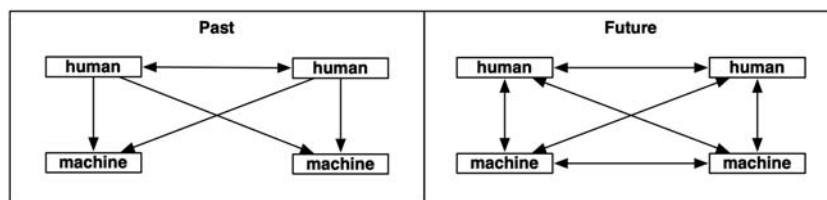


Figure 1 Shift of communicative interaction between humans and machines

competitive strengths of one culture and apply them to another in order to generate competitive advantages while avoiding cultural clashes. Using the basic logic of this competitive acceptance approach, HARM has to identify competitive strengths of both ARM and HRM and decide which of them should be maintained in HARM, for example automation process management from ARM and skill development from HRM.

Operational tasks: automation-people-nexus

The prevalent HARM task consists in the integrated configuration of any technological and human resources related to automation. It is oriented towards the essential preconditions needed for the digitization of the manufacturing process in smart factories. This means at least programming, information systems infrastructure such as cloud technologies, and also process and data security (Friess, 2013), the provision of skills, the psychology of human-machine collaboration, and leadership. With regard to this, the related financial investments have to be made. This corresponds to the main objective of creating a resilient automation-people-nexus while lowering transaction costs.

In order to achieve a systemic integration and to fully exploit the synergistic potential, certain critical success factors need to be addressed. Critical success factors are organizational actions that improve the success of the business and increase the competitiveness (Rockart, 1979). Especially in the context of HARM, the critical success factors have to be related to the specific change process requirements at the intersection of humans and robots. In their recent research, de Sousa Jabbour *et al.* (2018) derive a framework from existing literature focusing on the synergy between Industry 4.0 and environmentally-sustainable manufacturing. While de Sousa Jabbour *et al.* (2018) are looking at the ecological dimension of sustainability, the model can also be applied to the social dimension of sustainability, as both are crucial pillars for sustainability development (UN, 2005). It contains the following 11 critical success factors that need to be considered for successful synergy: management leadership, readiness for organizational change, top management commitment, strategic alignment, training and capacity building, empowerment, teamwork and the implementation team, organizational culture, communication, project management, and national culture and regional differences. In the following, we will adopt these critical success factors for the operational tasks of HARM integration.

- 1 Enhancing *management leadership* effectiveness (Samani *et al.*, 2012). Pursuant to the ‘Three Laws of Robotics’ (Asimov, 1942), any type of automation

has to serve humans unconditionally. According to Brynjolfsson and McAfee (2014), meanwhile, automation has become the leader with decisions made by a robot being superior to those made by a human (Lisi, 2015). It is, therefore, essential to lead a differentiated discussion of leadership design both of individuals and of teams. Humans and robots work ‘elbow to elbow on the shop floor’ (Bourne, 2013, p. 39) and team dynamics will be heavily affected. As an interesting example, humans have started to develop emotional connections to robots: some humans even name their vacuum cleaner (a machine) and view it as a member of their household (Biever, 2014).

- 2 Making the *organization ready for change* (Jones *et al.*, 2005). Especially for the humans, the transformation of smart manufacturing will be extensive. Work procedures will transform, and many new skills will be required. At the same time, some jobs will become obsolete, new jobs will emerge. It is a time of uncertainty (Magruk, 2016), therefore, it will be essential to tackle individual as well as collective change readiness (Rafferty *et al.*, 2013).
- 3 Achieving long-term *commitment of the top management* (Young and Jordan, 2008). Smart manufacturing incorporating HARM integration will lead to extensive changes and, furthermore, will be a long-term project for the organization. It will be decisive, how the top management behaves and communicates their actions to the employees (Dong *et al.*, 2009). Without a long-term commitment to the vision behind HARM, employees will lose faith in this organizational change.
- 4 *Aligning integration strategy* with the general strategy (Burn, 1993). Especially the development of new technologies in the context of smart manufacturing is often de-coupled from the general strategy and predominately determined by technological necessities. This is dangerous in times of increasing automation as organizations lack competitiveness without a strategic alignment (Avison *et al.*, 2004). The adoption of new technologies requires a fit with the organizational goals and, therefore, strategic fit is essential to sustain organizational survivability.
- 5 *Training and capacity building* for humans and robots (Katz and Margo, 2013). Job-related knowledge requirements that have become obsolete need to be replaced with knowledge requirements becoming more relevant to the automation of the new smart manufacturing environment. HARM will not only have to revisit all job descriptions but also to accompany all employees in their life-long learning (Mavrikios *et al.*, 2013) and their capability of adapting to new technologies more intensively (Weinberg, 2002; Khanagha *et al.*, 2013), increasing

- employee employability especially within the realm of unskilled labor (Hecker, 2001).
- 6 Reinforcing *empowerment* and participation (Cotton *et al.*, 1988). It may be the fast-selling reasoning that robots will become far superior than humans in the future of smart manufacturing, however, this will depend on the interaction between human and robots. In this new environment, proactive behavior (Boudrias *et al.*, 2009) will lead to changes and development that will be beneficial for the usage of robots in smart manufacturing. Empowered employees will tinker and play with robots and, by that, find new innovative ways for using the robots.
 - 7 Impacting human-robot *teamwork* and the *implementation team* (Groom and Nass, 2007). The HARM integration and the utilization of synergy will have a breaking point at the human-robot teamwork. The fact that human and robots will work together is the foundation of the HARM integration and is essential for steady advance of smart manufacturing (Scassellati and Hayes, 2014). It may not be the case that robots will trust humans, but humans will require a certain trust and want to share values, and emotions with their new ‘colleagues’ (Jones and George, 1998).
 - 8 Advancing *organizational culture* (Charalambous *et al.*, 2015). HARM will have to change the collective, corporate-wide mindset. As humans and robots will be working together more closely than ever, organizational culture will have no choice but to embrace this kind of cooperation (Ford, 2015), especially as there will be some resistance to this change at the beginning (Ford *et al.*, 2008). HARM’s cultural function will consist in establishing a culture of mutuality, openness, and collaboration.
 - 9 Ensuring future appropriateness of languages and *communication* (Mavridis, 2015). The selection of a common language and fruitful communication are already difficult between humans. The interface between humans and machines renders the task even more complicated. Both have completely different languages. Humans need to understand and emulate computational logic and machines need to interpret meaning. Whether or not there should be a communicative barrier between machines and humans, has to be classified at the level of the organization (Klein *et al.*, 2004). Improvements in this communication will be necessary in order to share knowledge and skills accordingly throughout the organization.
 - 10 Opening of HARM to collaborative networks and *projects* (Andres and Poler, 2016). Since the automation of manufacturing and its related services and projects takes place in company-spanning consortia and in increasingly open cross-company innovation networks (Chesbrough, 2003), HARM is expected to provide information-system-based technologies for network collaboration. They prepare people as well as the automated manufacturing for these network structures (Pan and Leidner, 2003) in order to integrate them as enablers and to retain people in these networks, for example by means of group management (Reagans and McEvily, 2003).
 - 11 Managing value creation in global production (Coe and Yeung, 2015) in regards of *national culture and regional differences*. In the past, many organizations have outsourced their production to low-cost countries. Since many of these countries have caught up in wage level for humans, the arbitrage between the costs of human labor and costs of machine labor will become the new major driver of location shifting of smart factories (Baldwin and Evenett, 2015). Increasing automation is expected to turn out to be a reason for bringing production back to the home-country, helping to secure jobs and thereby fighting technological unemployment – at least at home. In particular, the relocation of manufacturing brings a positive secondary effect as data no longer need to be transferred around the globe, which makes smart factories less susceptible to cyberattacks and increases cybersecurity (Wang *et al.*, 2016).
- In summary, it becomes evident that the HARM integration is necessary for smart manufacturing and has to be operationally prepared in order to achieve a synergy in terms of social sustainability. As de Sousa Jabbour *et al.* (2018) stated in their conclusion, the topic of smart manufacturing or Industry 4.0 and sustainability have been researched separately. However, both topics are interconnected, and an integrated approach is essential, especially in terms of survivability of a business. This is the same for the human dimension in smart manufacturing as the humans will be strongly impacted by this re-shaping of manufacturing. The human will play an integral role in the critical success of smart manufacturing, but only by harvesting the potential through a synergy with robots, thus, by HARM.

Efficiency: cost balancing

Businesses that reflect upon establishing the HARM function are expected to balance the cost of renewal towards HARM and profitability of this synergetic structure. They can do so by organizing the change process in terms of production networks, an approach that can be described in its wider complexity by the value net model from strategic management and by a layer model from network research (Ehrenmann, 2015). Based on that description, the ‘balanced resilience change management’ (Ehrenmann, 2015, p. 153) targets the performance both of the change interventions and of the change outcomes.

In particular, this approach is an example for the handling of the dilemma of building up transitional solutions, that is, leading to quick wins accompanied by low installing costs on the one hand, but to high costs of the makeshift dissolution if the final solution should be stabilized at an early stage (Reiß, 1997). The related cost and performance model covers, among others, efficient and effective uses of communication, learning, workflow transitions, and strategy implementation. In the context of HARM, optimization of such transaction costs can for example benefit from pre-existing dynamic network capabilities in ARM, or from pre-existing learning experience in big data-based prediction capabilities in HRM.

Conclusion: more than ‘mostly HARMless’

This paper is a conceptual starting point in the discussion on the managerial consequences of automation for manufacturing companies and the evolutionary integration of people-related interests. Contrary to the literature that points out the dangers (e.g., BGIA, 2009; Baggaley, 2010; Wallach, 2010; Brynjolfsson and McAfee, 2011; Simonite, 2014), we are pursuing a constructive approach towards the situation, sketching the interaction and collaboration of the two functions that are engaged in shaping both the technological as well as the human side of – and especially the human role in – automation. This understanding is a shift in the current automation discourse and a necessary contribution for practice, at least in the specific context of smart factories that in a way can serve as a pilot scheme.

One of the main contributions of the concept offered is that HARM is the seed what is needed to bring new socio-technological innovation to businesses. HARM can be perceived as an escape strategy both for ARM and HRM that are under massive pressure in their fight for survival. From the perspective of the former ARM, a broadening of the functional scope sets in, enriching ARM tasks with ‘the human side’ of automation. In Japanese, such enrichment is called *Jidōka* (Baudin, 2007), which denominates an ‘automation with a human touch’ and humanization of machines (Mori *et al.*, 2012). From the perspective of the former HRM, the institutionalization of HARM represents an upgrade in the sense of technology-orientation as a preferable alternative to downsizing and outsourcing (Delmotte and Sels, 2008). HARM allows for the opportunity of not only maintaining but also strengthening people issues as an integral part of automation. As examples of smart factories such as Tesla show, automation alone will not automatically lead to the pinnacle of efficiency, because ‘overestimating automation, underestimating humans’ (Pesce, 2018) proves suboptimal.

Managing the automation-people-nexus in one single function will render the institutionalized HARM the core resource-oriented department for the future innovativeness of smart factories. In the sense of the resource dependence approach (Pfeffer and Salancik, 1978), the HARM function supports corporate top management by providing the business with future directions and securing both the internal and the external resource base. The HARM function allows the dynamic utilization of capabilities to the fullest capacity. In the sense of new institutionalism (Zucker, 1988; Powell and DiMaggio, 1991), the HARM function has to meet the expectations of external as well as internal stakeholders, thus creating social legitimacy for the automation efforts of manufacturing companies.

It is important to distinguish HARM from an unrealistic, theory-driven vision. As a matter of fact, it has already become a reality and meanwhile, factories in the automotive industry (Arup, 2015; Deuse *et al.*, 2015) are systematically focusing on the interaction between human and automation in the sense of HARM. Starting from the point of process automation demands, these factories are thoroughly designed to be geared towards the requirements of the involved employees. Interestingly, this automation-people-nexus does not constitute a price increase or loss in quality but brings about a massive improvement of the product. A prominent example is the BMW factory in Regensburg, Germany which produces the 130i model, which is nicknamed the ‘zero-error-car’ and which received the highly prestigious Ludwig Erhard Prize (Engel, 2013) in 2013. In 2016, this prize was again awarded to the BMW Group works in Munich, in particular for successfully addressing continuous improvement, decision participation, employee health, corporate climate, and product quality as part of increasingly modularized and automated processes. The combination of humans and automation turns out to be a source of increasing effectiveness.

Although this paper contributes to the manufacturing context, it is an interesting subsequent question if HARM could be as well applied in a service industry context. The answer is ‘yes’, although the application is further afield as in smart factories. However, automation of services advances with high speed, using digitized technologies such as big data, prediction, and blockchain. Instead of robots, we would talk of automated systems (Bindi *et al.*, 2009; Bortolotti and Romano, 2012) or service bots (Pearce, 2017; Quinlan, 2017). For the integrated management of the automation-people-nexus, the challenge remains the same, so that HARM is to be extended to the service industry on the long run – as service is as well increasingly connecting up in a fragile network of humans and technology.

The visionary richness of the HARM concept lies in its potential to influence the social debate before us on a new

kind of diversity management. Much the same as gender-oriented diversity management started its triumph in businesses around the year 2000 by pointing out gender diversity as a source of enhancing individual and team contribution of both sexes to the organization's objectives (Dwyer *et al.*, 2003), an automation-oriented diversity management sketched out by the HARM concept could be the starting point for the efforts of enhancing individual team contributions of both technological and biological life focus to the organization's objectives. In combination with raising artificial intelligence (e.g., Wright and Schultz, 2018), questions of synergy between humans and robots will be increasingly important but challenging, for example, how will humans react if robots fill management positions?

Adverse consequences of promising synergy opportunities which are missed are depicted in Douglas Adams's (1992) fifth book of the 'Hitchhiker's guide to the galaxy' series titled 'Mostly harmless'. The guide characterizes Planet Earth as 'mostly harmless', describing it as an organic computer in a symbiotic relationship with its Earthlings who are trying to solve the 'ultimate Question of Life, The Universe, and Everything'. Because the potential of this synergy was ignored and a by-pass road appeared to be more productive, Earth ends up being blasted. Metaphorically speaking, that is what needs to be avoided in manufacturing reality. Especially in the context of smart factories, we are facing a by-pass road that will ultimately elude humans and focus solely on automation. In order to build a better world for humans in reality – and not take the by-pass road – it will be of major necessity to discuss the beneficial outcomes of a synergistic collaboration of humans and machines and the institutionalization of a HARM function that manages the resources from a single source. If successful, HARM could not be further from being 'mostly HARMless'!

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