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Smart HRM – a Delphi study on the application and consequences of the Internet of Things in Human Resource Management

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ABSTRACT
The Internet of Things ('IoT') refers to the ability to connect physical objects ('things') to the Internet, and this connection enables things to behave autonomously in a context-adequate manner and thus to become 'smart'. Based on the broad range of application possibilities, the current paper aims to explore the possible future application and consequences of the IoT in HRM by conducting an explorative Delphi-study with 40 IoT-experts. The results of the study reveal the application of the IoT in HRM to be perceived as a likely development in the near future. The results also uncover various consequences of the IoT in HRM. The expected adoption of the IoT in HRM will first change HR technologies, i.e. the hardware, software and data of HRM. Second, the changes also involve larger modifications of HR activities. However, these activities are affected in different intensities. Third, the application of the IoT is also expected to noticeably change tasks and qualifications of HR actors. In summary, the current study indicates that smart HRM will constitute both a likely and relevant future development that needs deeper consideration.

KEYWORDS
Smart HRM; Internet of Things; smart things; smart work; e-HRM

1. Introduction – IoT and HRM

The Internet of Things ('IoT') refers to the ability to connect physical objects ('things') to the Internet and thus equip them with the unprecedented functionality of autonomous context-adequate behaviour. Thus, physical objects that are connected to the Internet are called 'smart things' (or 'cyber-physical systems', as an earlier designation). Consequently, the IoT is broadly discussed as a future core technology with the potential for disruptive changes (e.g. Ashton, 2009; Atzori, Iera, & Morabito, 2010; Borgia, 2014; Chui, Löffler, & Roberts, 2010; Fleisch, 2010; Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012; National Intelligence Council, 2008). At present, there is a broad range of actual and potential IoT application

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domains. Following an established naming convention, such application domains are designated with the prefix 'smart' (e.g. Guillemin & Friess, 2009; Vermesan et al., 2013). It is expected that business, in particular, constitutes an important future application domain (e.g. Fantana et al., 2013; Fleisch, 2010), and there are already diverse business application domains, such as smart manufacturing (e.g. Chand & Davis, 2010), smart logistics (e.g. Resch & Blecker, 2012), smart retailing (e.g. Pantano & Timmermans, 2014) or smart health (e.g. Solanas et al., 2014).

In these application domains, larger and even disruptive changes with copious opportunities and threats are expected. Consequently, broad research initiatives accompany the emerging application of the IoT to contribute to a better understanding of its application and consequences (e.g. Baiyere et al., 2016; Miorandi et al., 2012; Vermesan et al., 2013). As a prominent example, manufacturing research has notably turned towards 'smart manufacturing'. This is manifested in a large number of research contributions regarding the IoT in manufacturing. In the meantime, smart manufacturing is widely understood as a 'new paradigm' and 'the fourth revolution' of manufacturing (e.g. Kang et al., 2016; Thoben, Wiesner, & Wuest, 2017).

Contrary to these developments, in HRM the IoT does not seem to be a topic of larger interest, and so far, there are very few publications on the topic (Habraken & Bondarouk, 2017; Bondarouk, Ruël, & Parry, 2017). The initial research first refers to new possibilities that the IoT offers for HRM. In particular, technical disciplines developed a few application scenarios of the IoT in HRM. These scenarios first refer to employing smart things for advanced automation of HRM, such as automating HR training by smart things that novice users autonomously introduce into their usage (e.g. Charmonman, Mongkhonvanit, Dieu, & Linden, 2015; Watson & Ogle, 2013). These scenarios secondly refer to employing smart things for advanced HRM information, such as sensing HR information including staffing requirements, working times, qualification deficits or break needs (e.g. Bersin, Mariani, & Monahan, 2016; Mathur, Broeck, Vanderhulst, Mashhadi, & Kawsar, 2015; Waber, 2013). Furthermore, the initial research refers to the changes caused by the IoT in HRM, such as changes in job design (Habraken & Bondarouk, 2017) or workforce systems (McDonald, Fisher, & Connelly, 2017).

Beyond these studies, however, there is so far no systematic HR research into smart HRM, and the term is still unfamiliar in HRM. This lack of research is bearable if the IoT – contrary to its substantial relevance in other domains and despite the emerging HR application scenarios – actually does not matter in HRM (e.g. Looise, 2016). It is, however, problematic if the IoT constitutes an important emerging technological development with relevant opportunities and the potential for threats to HRM. In this case, the research should aim at proactively investigating this technological development to support the utilization of potential opportunities and the avoidance or reduction of potential threats.

It is against this backdrop that the current paper aims to explore for the first time the potential future *application and consequences of the IoT in HRM*. To uncover whether the IoT is of basic relevance for HRM requires a deeper consideration its future application. Thus, the first research question is as follows:

RQ 1: Will the IoT be applied in HRM?

Moreover, to uncover the potential opportunities and threats of the application of the IoT in HRM and thus to identify critical issues that need deeper future considerations, the future consequences are explored. Thus, the second research question is as follows:

RQ 2: Which changes will an application of the IoT induce in HRM?

Exploring both questions should thus contribute to an initial appraisal of the IoT in HRM and provide a starting point for potential future activities.

To realize this, a simple framework that establishes the application of the IoT in HRM is initially elaborated (Section 2). Based on this framework, an explorative Delphi study is introduced and substantiated (Section 3). Subsequently, the major results of the Delphi study are presented (Section 4). The paper closes with a discussion of major conclusions (Section 5).

2. Framework – context and configurations of HRM

2.1. Overview

To research the application and consequences of the IoT in HRM in an informed, reasonable and defensible way (Ravitch & Riggan, 2016), in the following, an existing framework of technology-based HRM (Strohmeier, 2007) is adapted as the foundation of the current study. The framework rests on a configurational perspective, conceptualizing HRM as a configuration of different interacting elements, which emerges within the frame of an external context with different dimensions (e.g. Meyer, Tsui, & Hinings, 1993; Misangyi et al., 2017; Short, Payne, & Ketchen, 2008).

While conceptualizing HRM configurations, the interaction of *HR actors*, *HR activities* and *HR technologies* is considered in the framework as a minimal model of relevant configurational elements (Strohmeier, 2007). HR actors refer to individuals or a group of individuals who interact in performing diverse HR activities. HR activities refer to the set of practices that are necessary to provide employees with the required abilities, motivation and opportunities to perform. Finally, HR technologies refer to the set of networked hardware, software and data that is applied by HR actors to support and complement them in performing HR activities. Based on these three elements and their interaction, a base description of technology-based HRM configurations becomes possible.

Conceptualizing the HRM context, different relevant dimensions, such as the cultural, institutional or technological context of HRM, are considered in the framework (Strohmeier, 2007). Against the backdrop of the configurational perspective, lasting changes in one or more of these dimensions can trigger lasting changes in configurations (e.g. Meyer et al., 1993; Misangyi et al., 2017). Given the abovementioned research topic, the technological context is particularly relevant, and the IoT is understood as a major change in the technological context of HRM that – via offering new possibilities and posing new requirements – shows the potential to change HRM configurations. As a vivid example, more than two decades ago, the advent of the Internet caused profound changes in the actors, activities and technologies of HRM (see the results of Strohmeier, 2007 and Bondarouk, Parry, & Furtmueller, 2017).

In this way, the framework conceptualizes the IoT as a change in the technological context of HRM that might show the potential to induce certain changes in the configuration of HRM (see Figure 1).

Thus, the following sections elaborate on the context and configuration as relevant for the current study.

2.2. IoT as the technological context of HRM

As the core change in the technological context, the major characteristics of the IoT are briefly elaborated as follows. The IoT refers to the ability to connect physical objects ('things') to the Internet. Since any physical object can be connected to the Internet, there is a heterogeneous abundance of connectable things – such as cars, shutters, pacemakers, aircraft turbines or impact wrenches – that is beyond any enumeration (e.g. Fleisch, 2010; Zotta, Timofte, & Constantinescu, 2010). The resulting functionalities of things connected to the Internet refer to the three interrelated technical functions of sensing, actuating and interacting (e.g. Chui et al., 2010; Flörkemaier & Mattern, 2010; see Figure 2).

Sensing constitutes the first technical function that refers to the measurement of diverse variables and the transmission of the measured data to the Internet. Sensing is realized based on sensors placed at the thing. Sensors are able to measure an abundant variety of different thing- and environment-related variables, such as location, velocity, temperature, state of usage, malfunction, stress, etc. (e.g. Borgia, 2014; Swan, 2012; Weston, 2015). The basic result of sensing is that the information is new, highly detailed, real-time, automatically generated, trustworthy and voluminous (e.g. Borgia, 2014; Fleisch, 2010). *Actuating* constitutes the

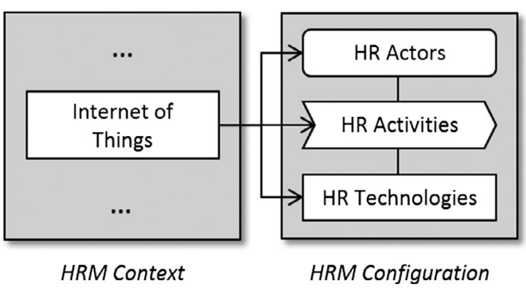

Figure 1. Framework (adapted from Strohmeier, 2007).

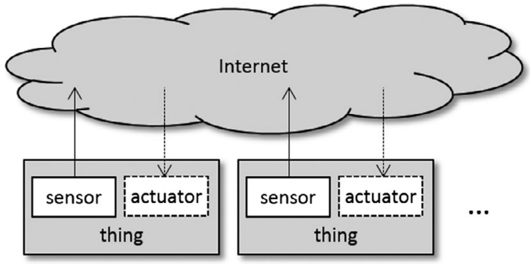

Figure 2. Connecting the Internet and things.

second general function that refers to remote controlling of a thing (e.g. Borgia, 2014; Chui et al., 2010). Actuating is realized by means of one or more actuator(s), i.e. physical devices that control a thing and, to this end, are usually physically embedded in or physically attached to the respective thing. Thus, the major result of the actuating connection is the control of the thing, and this control is context-aware, remote, (optionally) automated and real-time (e.g. Borgia, 2014; Chen, 2012). *Interacting* constitutes the third general function that refers to the coordination and mutual exchange of information between different things (a synonym is 'machine-to-machine/M2M'; e.g. Darmois & Elloumi, 2012; Chui et al., 2010). The interaction considerably expands the functionality of things since it allows for a coordination of functions and the utilization of complementary functions of different things (e.g. Guillemin & Friess, 2009; Miorandi et al., 2012).

The purposeful interaction of these three functions of smart things equips them with the unprecedented functionality of *autonomous context-adequate behaviour*. Since such behaviour would require intelligence if performed by humans, the notion of '*smart things*' is broadly used (e.g. Fleisch, 2010; Vermesan et al., 2013). Smart things are thus *physical objects that are connected to the Internet*. Smart things constitute the building blocks of the IoT, which can be defined as the *entirety of interconnected smart things* (e.g. Borgia, 2014; Flörkemaier & Mattern, 2010).

If smart things are employed in organizations, the *technical functions* of sensing, actuating and interacting translate into the *organizational functions* of automation and information (Zuboff, 1988). First, the sensing, actuating and interacting of smart things massively expand organizational *automation potentials*. Smart things allow for automating tasks that, due to their complex perceptive-cognitive and physical-motoric requirements, were not automatable before (e.g. Borgia, 2014; Chand & Davis, 2010). Increasing automation potentials can also be expected for an application of the IoT in HRM, which can be illustrated based on different application scenarios discussed in the extant literature. A first automation scenario uses smart tools in training to introduce novice users to tool handling and application in a fully automated manner (e.g. Charmonman et al., 2015; Dlodlo, 2012). A second automation scenario uses smart things for workforce planning and scheduling in manufacturing. The sensors of the interacting smart tools and work pieces can be used to determine the quality, quantity and time period of manufacturing employees and then offer input for scheduling algorithms that fully automate the scheduling of manufacturing employees (e.g. Spath, Gerlach, Hämmerle, Schlund, & Strölin, 2013). A third automation scenario refers to health management based on sensors that measure employee stress, physical fatigue, exercise level, etc. and algorithms that transform these data into health suggestions for employees, such as taking work breaks or increasing participation in sporting activities (e.g. Nihan, 2013; Solanas et al., 2014). Second, the sensing function of smart things (or concretely, sensors as parts of smart things) will massively expand the organizational *information potentials* (e.g. Fleisch, 2010; Swan, 2012). Smart things will allow for a vast amount of additional, previously unknown information that shows a high level of detail and is available in real-time. Again, clearly increasing information potentials are also to be expected for an application of the IoT in HRM. Sensors that employees use or wear during their work can generate a very broad spectrum of HR-relevant data (e.g. Swan, 2012; Waber, 2013). This might refer, for instance, to the requirements, such as pending tasks; qualifications, such as deficits in using a tool; performance, such as quality and speed of work; physical activity, such as physical motion, strain and fatigue; psychological state, such as stress levels; or social situation, such as the number and quality of interactions. In summary, the IoT is conceptualized as a set of connected smart things that show the potential to broadly expand the automation and the information of HRM.

2.3. Technologies, activities and actors as HRM configuration

Regarding the change in HRM configurations, it is obvious that any application of the IoT in HRM would first and foremost change current *HR technologies*. While HR technologies were subject to continuous change in the past (e.g. Stone, Deadrick, Lukaszewski, & Johnson, 2015), IoT-technologies have not been broadly adopted in HRM so far. Understanding *hardware*, *software* and *data* as the core components of HR technology that mandatorily have to interact to offer the intended functionalities (e.g. Kavanagh, Thite, & Johnson, 2014; Stone et al., 2015), it is obvious that an application of the IoT in HRM will change all three components. Understanding hardware as all physical components of an HR computer system, the adoption of the IoT would imply the usage of diverse smart things for HR purposes, e.g. for automating certain HR activities or for gathering certain HR information. Since these technologies have not been employed so far, these smart things would clearly complement the current hardware infrastructure of HRM. Moreover, since software constitutes a set of coded instructions stored and run by HR hardware, it is additionally obvious that current HR software needs modifications to realize the automation and information potentials of the IoT. Finally, understanding HR data as material representations of information that can be processed, stored and transmitted by the interaction of hardware and software, it becomes further obvious that HR data will also change due to future

IoT applications. In particular, based on the numerous sensors of smart things, a massive increase in data volume and velocity is to be expected. In summary, the framework conceptualizes HR technology as the intersection of HR hardware, software and data and expects interrelated changes in all three components if the IoT is applied in HRM.

HR activities refer to the set of employee-related tasks performed to provide the quantity and quality of employees required for an organization to reach its objectives (e.g. Ostroff & Bowen, 2000). Any application of the IoT in HRM does not constitute an end in itself but aims at improving HR activities. While there are some scholarly categorizations of HR activities, such as the AMO-framework (e.g. Boxall & Purcell, 2003), there is still 'tremendous variability' (Lepak, Liao, Chung, & Harden, 2006, p. 222) regarding single HR activities and their categorization. To explore the major influences of the IoT on activities, six HR activities are considered that are both relevant for the HR success contributions and frequently employed in practice (Lepak et al., 2006; Ostroff & Bowen, 2000). These activities are *HR information (*or *analytics)*, *HR recruiting*, *HR staffing* (or *deployment*), *HR performance management*, *HR development* and *HR compensation*. Even though necessarily incomplete, this set allows for a first exploration of potential changes, while the expected core changes refer to the automation and information of these practices. Understanding HR information (or analytics) as an activity that systematically gathers and supplies information relevant for HR decision-making, it is obvious that the sensing function of smart things might induce deep changes in the procedures and results of this activity (e.g. Waber, 2013; Weston, 2015; Wilson, 2013). However, the further activities might also be subject to information and automation changes. An already elaborated application scenario refers, for instance, to employing the technical functions of smart tools in employee training, for instance, to introduce novice human users autonomously to a proper application – therefore, offering an example of further automating the HR development activity. In summary, the framework conceptualizes HR activities as a set of six major functions and expects changes to these functions if the IoT is applied in HRM.

As a final configurational element, *HR actors* refer to the group of humans who collaborate in performing HR activities supported by HR technology. This refers to different actor categories within HR departments, such as senior HR managers or business partners, while there are also diverse actor categories outside the HR departments, such as line managers or HR service providers (e.g. Ulrich, 2007; Ulrich, Younger, Brockbank, & Ulrich, 2013). To limit the scope of the study, the framework concentrates on internal actor categories while explicitly acknowledging that external actor categories can also be affected by a potential application of the IoT in HRM. Assuming a hierarchical structure of internal HR positions, three ideal and typical levels can be distinguished: The *senior HR manager* refers to the highest senior HR position responsible for the general design and management of HR. *HR business partners* refer to positions that offer line management direct support and services. Finally, *HR administrators* refer to positions that perform numerous operative HR tasks, such as payroll processing or record keeping. Due to the IoT application, these actor categories might also be exposed to changes, such as changing scopes and contents of tasks and changing qualification requirements. In summary, the framework conceptualizes HR actors with three level-dependent internal position categories, and changes to these actors are expected if the IoT is applied in HRM.

3. Method – an explorative Delphi approach

3.1. Substantiation of the method

Since both research questions show a distinct prognostic character, there are only limited choices for suitable research methods. A well-established method for prognostic research questions is the *Delphi approach* (e.g. Grisham, 2009; Häder, 2014; Hasson & Keeney, 2011; Linstone & Turoff, 2011; Skinner, Nelson, Chin, & Land, 2015). The Delphi approach refers to a systematic iterative survey method with feedback provided by a panel of subject matter experts to estimate future developments. As preparatory steps, the participating experts need to be determined, and the questionnaire has to be developed (e.g. Hasson, Keeney, & McKenna, 2000; Hsu & Sandford, 2007). The implementation of the Delphi approach then refers to several iterative rounds of surveying the experts based on the questionnaire. After each round, the results are summarized and anonymously fed back to the participants to stimulate their reflection and eventually trigger modified answers in the next round (e.g. Hasson et al., 2000; Rowe & Wright, 2001). The core objective is to obtain a consolidated view of potential future developments in the subject under consideration.

Due to these characteristics, the Delphi approach also constitutes a feasible method for predicting technical and organizational developments, such as the future application and consequences of the IoT in HRM (e.g. Skinner et al., 2015). As a result, the Delphi approach offers an educated guess regarding these two questions and a justifiable basis for their future discussion. An exact and error-free prediction of concrete future developments, however, is beyond the possibilities of this (or any other) methodical approach (e.g. Hasson & Keeney, 2011).

3.2. Determination of participants

The participants of a Delphi study should be highly knowledgeable and competent (e.g. Hsu & Sandford, 2007) but also neutral and impartial (e.g. Grisham, 2009) regarding the subject under consideration. If there are different expert groups on the subject, the study should consider these different perspectives (e.g. Linstone & Turoff, 2011). Regarding the IoT in HRM, it is obvious that the perspective of *HR management experts*, as well as the perspective of *HR technology experts*, is relevant. Furthermore, since practitioners actually decide on future developments, while researchers provide deeper reflection and theories, the perspectives of *HR practitioners* and of *HR researchers* are also relevant. Therefore, four different groups – HR management practitioners and researchers as well as HR technology practitioners and researchers – are relevant and are thus considered in the study.

Regarding the adequate number of participants, there is a certain trade-off (e.g. Hasson & Keeney, 2011; Hsu & Sandford, 2007). On the one hand, the consideration of different opinions and the balancing of outlier opinions require a larger number of participants. On the other hand, the implementation effort and the limited availability of experts demand a smaller number of participants. Against this backdrop, 10 participants in each group and consequently 40 participants in total constitute a compromise. For each group, potential participants were identified based on the criteria of outstanding reputation (as manifested in publications, leading positions in professional associations, senior positions in their organizations, etc.) and personal familiarity with the IoT (manifested in participation or research in IoT-projects). Potential participants were contacted by telephone, and their participation was requested. Based on this procedure, 40 experts were recruited. The study was conducted in Germany, all experts were German, 37 of them were male, and 3 were female. The HR research experts were Full Professors of HRM, Organization and/or Management. The HR technology research experts were Full Professors of Business Informatics, Informatics or Information Systems. The HR practitioner experts comprised CHROs, senior HR plant managers and a project-manager of an HR-IoT project. Since the organizational application of the IoT in Germany is most advanced in manufacturing, all HR practitioner experts come large leading manufacturing companies. The HR technology practitioner experts were CTOs or software development/product managers complemented by a sales director – all from different HR technology vendor companies.

3.3. Development of the questionnaire

The questionnaire was developed in a two-step approach. In the first step, a group of four researchers developed an initial questionnaire. The questionnaire aimed to answer both research questions based on the abovementioned framework. The application of the IoT (RQ 1) was ascertained by items on the future change of HR technologies. The consequences of the IoT (RQ 2) were ascertained by items on the future changes in HR technologies (subcategories 'hardware', 'software' and 'data'), HR activities (subcategories 'information', 'recruiting', 'staffing', 'development', 'performance management' and 'compensation') and HR actors (subcategories 'senior HR manager', 'HR business partner', 'HR administrator' and 'general HR actors'). Potential changes were derived based on the technical characteristics of the IoT. The items were formulated as concrete change statements. For example, to determine the data from smart things that employees use, the item 'HR data will stem from sensors on smart things that employees use' (*item # 8*) was derived. For rating the agreement with the changes, five-point Likert scales (from 1 ['fully disagree'] to 5 ['fully agree']) were employed. To estimate the expected speed of change, the expected time until the changes occur was ascertained for each subcategory. The questionnaire was systematically pre-tested based on a mixed sample of four experts (e.g. Rowe & Wright, 2011). As a result, some ambiguous items were restated, some items were deleted, and diverse new items were included. When answering this questionnaire in the first Delphi round (see section 3.4), each expert was additionally asked to add further likely changes that were overlooked by the questionnaire. These additional changes were transferred into items that were incorporated into the second questionnaire. In this way, researchers *and* experts assembled a broad set of potential changes that allows for an initial exploration of the IoT in HRM (see Appendix 1).

3.4. Implementation of the study

To limit the effort and assure the acceptance of participants, the number of rounds was limited to two (e.g. Hsu & Sandford, 2007; Rowe & Wright, 2011). For reasons of convenience and speed of return, both questionnaires were conducted as online surveys (e.g. Hasson & Keeney, 2011). In the first round, each participant was sent an e-mail with a password and an introduction explaining how to access and use the survey website. To introduce the topic and create a common understanding, the questionnaire was complemented with written and visual information (e.g. Rowe & Wright, 2011). The results of the first questionnaire were summarized using bar charts, means and standard deviations and were included in the questionnaire for the second round. As a result, 37 usable questionnaires (92.5% response rate) were obtained after the second round (see Table 1), which clearly exceeds the acceptable response rates (e.g. Hsu & Sandford, 2007).

3.5. Analysis of results

To summarize the answers, the means and standard deviations for each item were calculated. To simplify the interpretation, the agreement rates 'AR' (proportion of fully/rather agreeing experts) and disagreement rates 'DAR' (proportion of fully/rather disagreeing experts) were additionally calculated. Both rates were combined to determine whether experts show *agreement* (AR > 0.5 and DAR < 0.2), *disagreement* (AR < 0.2 and DAR > 0.5) or *polarization* (AR > 0.33 and DAR > 0.33) regarding an item. Further imaginable combinations of AR and DAR were regarded as non-interpretable. While Delphi studies sometimes aim at achieving consensus among the experts (e.g. Hsu & Sandford, 2007; Okoli &

Table 1. Invited experts/usable return.

	HR management expert	HR technology expert	Σ
HR researcher expert	10/10	10/08	20/18
HR practitioner expert	10/09	10/10	20/19
Σ	20/19	20/18	40/37

Pawlowski, 2004), the current study also accepted dissensus ('polarization') as an interesting and valuable result (e.g. Linstone & Turoff, 2011; Steinert, 2009).

Beyond individual changes, the analysis also aimed at offering an aggregated overview of the results that allows 'important' changes to be distinguished from 'less important' ones. To this end, the two dimensions of the *intensity* and *speed of change* are used to operationalize the importance of changes. High intensity and speed of change indicate important changes since related changes are comprehensive and occur fast. Contrarily, low intensity and speed indicate low importance since the respective changes are marginal and occur slowly. For determining the intensity of change, the mean of all items in a subcategory, such as HR data, was used. To indicate the speed of change, the results of items during the time until the occurrence of the change were used. To distinguish 'faster' changes from 'slower' ones and 'intensive' from 'insignificant' changes, both dimensions were bisected based on the Likert scale. The cut-off point for the intensity of change was the value of 3 ('partly disagree / partly agree'), i.e. values higher than 3 indicate that experts on average agreed to the related changes, while values lower than 3 indicate that experts on average disagreed with the respective changes. The cut-off point for the speed of change was again the value 3 ('6–9 years'), i.e. values higher than 3 indicate that the change will occur only after 9 years or later (categorized as slow change), while values lower than 3 indicate that it will occur within 5 years (categorized as fast change). Based on the two bisected dimensions, the change diagrams consist of four quadrants that refer to slower insignificant changes (I), faster insignificant changes (II), slower significant changes (III) and faster significant changes (IV) (see Figures 3–5).

To consider the potentially differing degrees of expert competences, in addition to unweighted results, weighted results considering the self-reported competence levels with a 0-1-2-3 weighting were calculated (e.g. Häder, 2014; Rowe & Wright, 2001). To test expert group differences, the Kruskal-Wallis test (Kruskal & Wallis, 1952) and the Wilcoxon rank-sum test (Wilcoxon, 1945) were employed based on the preceding Levene tests (Levene, 1960).

4. Results – application of the IoT and changes in HR configurations

Corresponding with the large number of items, the study yielded numerous detailed results (see Appendix 1). The following section focuses on the most interesting results. To do so, first, the general results referring to the differences between the two rounds, overall distribution of answers, potential differences between participant groups and competence levels are elaborated. Subsequently, the results related to HR technologies, HR activities and HR actors are provided by presenting the aggregated results in change diagrams and then elaborating the most interesting phenomena of change.

4.1. General results

A first general result refers to the changes in answers from the first to the second round. While 27 experts (72.5%) made changes, only a few items were changed (M = 3.9 [5.8%]/SD = 2.5). In addition, it should be noted that the intensity of change was rather moderate (M = 0.1/SD = 1.1/MAX = 2). There were mostly slight changes in the same (agreeing or disagreeing) direction, while radical changes of opinion did not occur. Moreover, thematical patterns of change did not arise, i.e. changes were arbitrarily scattered over the different areas. In summary, this represents rather stable responses across the two rounds.

A second general result refers to the distribution of the respective items to the categories of *agreement* (65.6%), *disagreement* (9.8%), *polarization* (3.3%) and *non-interpretability* (21.3%). Given that all items stated changes, the fact that nearly two thirds of the items gained agreement and less than a tenth of the items gained disagreement uncovers a general result of the study: Experts expect that the IoT will be applied in HRM and will induce numerous changes in HR technologies, activities and actors. Polarization and therefore dissensus among the experts is limited to very few items. However, one fifth of the items still show rather scattered results that are difficult to interpret. Looking for thematic areas with a clear focus on agreement, disagreement, polarization or non-interpretability had the following result: only the items on 'HR awareness and state' (*items # 65–67*) showed consistent disagreement. Experts generally disagree that HRM has recognized the relevance of the IoT, is able to cope with the requirements of the IoT, and plays an active role in the implementation of the IoT. Further thematic (dis-)agreement or polarization patterns were not found.

As a third general result, the consideration of different self-rated *levels of competence* (e.g. Häder, 2014; Rowe & Wright, 2001) did not yield significant differences. Generally, the self-ratings of experts showed rather high competence values. This is illustrated by the fact that only one of the participants did *not* feel competent regarding only one of the research areas ('HR technologies'). The majority of participants felt competent or even highly competent. This supports the selection of participants as renowned thematic experts. Consequently, the subsequent discussion of results does not require any differentiation between the different self-reported competency-levels of participants.

As a fourth general result, few differences between *expert groups* could be detected. First, the comparison of all four groups revealed that only 14 items (15.4%) show significant differences. HR technology practitioners tend to be more convinced of the changes described by these items. Differences are scattered over single items and do not show clear thematic clusters. As an exception, the items on 'HR awareness and state' (*items # 65–67*) constitute a thematic cluster: HR technology researchers constituted the most sceptical group, followed by HR management researchers, HR technology practitioners, and HR management practitioners as the least sceptical group. Second, the comparison of *practitioner and* *researcher experts* revealed even less disagreement; only 5 items (5.5%) showed significant differences. Practitioners are more convinced of the changes quoted by these items compared to researchers. A thematic cluster refers to differences in the interaction of HR software with the IoT (*items # 4, 5*). Regarding this, practitioner experts are significantly more convinced that HR software will directly or indirectly interact with the IoT. Third, the comparison of *HR management and HR technology experts* showed significant differences in 16 items (17.6%). HR technology experts are more convinced that the respective changes described by these items will occur. A thematic cluster again refers to 'HR awareness and state' (*items # 65–67*). HR technology experts are significantly less confident that HRM recognizes the relevance, is able to cope with the requirements and shows an active role in the implementation of the IoT. Regarding the future distribution of HR tasks (*items # 59–60*), HR technology experts are significantly more confident that the HR department will perform fewer tasks, while line managers and employees will take over more HR tasks. In summary, HR technology experts and HR practitioner experts tend to be more convinced of the application and changes of the IoT in HRM. However, in the vast majority of items, there are no such significant differences. This uncovers a generally rather stable and robust judgement across different perspectives (Hasson & Keeney, 2011).

4.2. HR technology results

The items on HR technology refer to the changes in HR hardware (items # 1–3), HR software (items # 4–7) and HR data (items # 8–12) due to possible future applications of IoT technologies. Figure 3 reveals that HR hardware, software and data are located in quadrant IV, indicating significant and fast changes.

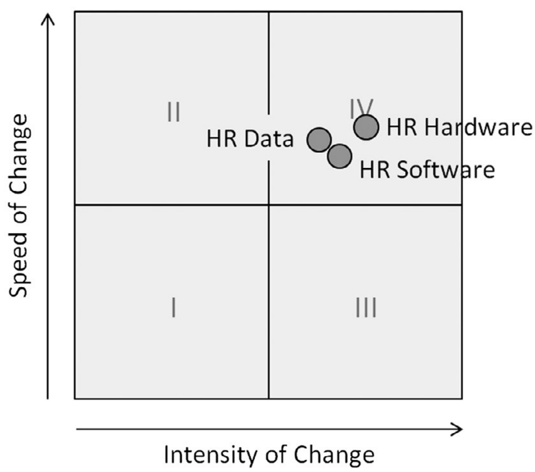

Figure 3. Change in HR technologies.

Substantiating this, a first interesting change refers to the expert prediction that smart things will actually constitute a new category of HR hardware (*item # 1*). The belief that HR activities will actually employ smart things is supported throughout the questionnaire (e.g. items # 8, 20, 28, 29, 33, 35) and thus is specified in the following sections. The predicted automation of HR tasks by smart things constitutes a first interesting change that might be termed *reification of HRM*. Evidently, this constitutes the first clear indication of a future application of the IoT in HRM.

In the same way, experts broadly accept the future usage of sensors for ascertaining HR data (*item # 2*). Again, further items (e.g. items # 19, 20, 28, 34, and 38) support the respective application areas. Regarding the location, it is agreed that sensors will be located on the things the employees use at work, such as tools or workpieces (*item # 8*). In addition, the usage of wearable sensors placed on, e.g. the wristbands, clothes or glasses of employees is expected (*item # 9*). This predicted systematic usage of sensors of different types to ascertain HR data might be termed *sensorization of HRM*. Given that the sensorization constitutes a highly sensitive issue regarding privacy, acceptance and co-determination, particularly in the German context, this is an unexpected and interesting result. Obviously, the experts assume that the problem of extensive employee surveillance inherent to sensing (e.g. Motti & Caine, 2015; Weston, 2015) is manageable. Echoing the reification, the sensorization also constitutes a second clear indication for the future application of the IoT in HRM.

Moreover, to enable a systematic coordination of HR measures with the operative HR requirements of business, the experts predict that future HR software will interact with the IoT. A slight majority of the experts predict this interaction to be direct, i.e. HR software will show direct connections to sensors and smart things to receive data and provide digital services (*item # 4*). For instance, future learning management systems might interact with the IoT to deliver real-time training to smart things if sensors indicate a qualification deficit of one of its users (*item # 29*). Furthermore, most experts agree that the connection of HR software and IoT will additionally be of an indirect nature, i.e. HR software interacts with further organizational software that directly interacts with the IoT (*item # 5*). This phenomenon of the future direct and indirect connections of HR software and the IoT might be termed the *technical linkage of HRM*.

Directly related to sensorization, the experts also expect an exponential growth of HR data volume, variety and velocity and thus the emergence of '*big HR data*' (*item # 10*). The usage of multiple sensors across multiple smart things ('sensor swarms') will yield an abundant volume, an increased variety and a fast re-occurrence of HR data (e.g. Fleisch, 2010; Swan, 2012). This systematic mapping of an ever-increasing number of HR-relevant aspects with highly detailed real-time data can be used to systematically and comprehensively inform HRM. For instance, if employees enter certain danger zones – e.g. firefighters enter a burning house – wearable sensors can systematically measure aspects such as body temperature, respiration, and pulse to enable management interventions to ensure the health and occupational safety of employees (e.g. Intel, 2015). Constituting an established general designation, the term *datafication of HRM* is used to designate this expected change (e.g. Lycett, 2013).

In summary, the experts expect noticeable changes in HR technology due to the adoption of the IoT, and they expect these changes to occur within the next 5 years. As mapped by the interrelated phenomena of reification, sensorization and technical linkage of HRM, the experts understand HRM as a further application domain of the IoT. Smart HRM thus constitutes a very likely future development.

4.3. HR activities results

Items on HR activities refer to the change in HR information (*items # 13–18*), recruiting (*items # 19–22*), staffing (*items 23–27*), development (*items 28–32*), performance management (*items 33–37*) and compensation (*items # 38–42*). Again, the aggregated results on speed and intensity of change can be visualized in a change diagram (see Figure 4).

This aggregated view uncovers a first interesting result, as a bisection into two sets of HR activities becomes apparent. A first set of activities – HR information, staffing and development – is located in quadrant IV. Based on the detailed results, these three activities tend to be realized as 'smart' HR activities, i.e. the *reification* and *sensorization,* as described above, are particularly valid for these activities, while further changes, as described below, particularly apply for these activities. A second set of HR activities – HR recruiting, performance and compensation – however, is located between the quadrants IV and II, which indicates insignificant or only moderate changes in these activities. The detailed results uncover that expert expectations of whether these functions will also become 'smart' in the

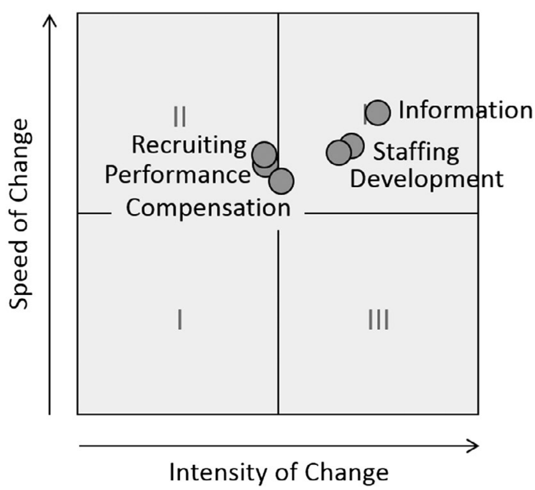

Figure 4. Change in HR activities.

future are rather split. While only the results for HR staffing showed an explicit polarization as defined above (*items # 19 and 20*), the results for HR performance management (*items # 33 and 34*) and for HR compensation (*item # 38 and 39*) are only slightly below the polarization level. Taken together, there is agreement among experts that the first set of HR activities will become 'smart' and change, while there is disagreement regarding the second set of HR activities. However, these results revealed an interesting insight: not all HR activities might become smart at equal speed and intensity, and there might be differences in the 'smartness' of HR activities. The managerial desirability and technical feasibility may play a role in the search for factors that influence the degree of 'smartness' of HR activities. For instance, it might be managerially undesirable to use sensors in performance management to appraise employee performance in real-time and high-resolution (*item # 34*) since this implies over-surveillance. Moreover, it might be technically not feasible to use smart things to fully automate selections (*item # 20*), since the social qualifications of applicants also have to be considered. Employing technical feasibility and managerial desirability, however, is just an initial attempt to explain the adoption of the IoT in different HR activities. The actual drivers and concrete patterns of a future adoption of the IoT in different HR activities constitute a prominent future research issue. In summary, the prediction that different HR activities will show different intensities of 'smartness' constitutes a first interesting insight; the underlying phenomenon of change might be called *activity-specific adoption differences* in HRM.

A second change phenomenon refers to the general acceleration of HR service delivery, while this applies particularly to the first set of HR activities, i.e. HR information, staffing and development. Regarding HR information, sensors can drastically reduce the time span between the occurrence of an HR-relevant event and the provision of information about the event ('latency') (e.g. Fleisch, 2010; Swan, 2012). Experts clearly expect that the 'sensorization' of HRM will reduce the latency of HR information (*item # 15*). As such a reduction of HR information latency allows for faster HR decisions and for faster HR service delivery, this must be understood as a clear improvement (Hackathorn, 2003). Beyond HR information, it is also expected that HR staffing will accelerate and be performed in near- or even real-time (*item # 23*). Since in increasingly more business domains diverse smart things will autonomously interact to support the provision of intended products and/or services, it is expected that operational staffing requirements will increasingly emerge in an ad hoc-manner (Guillemin & Friess, 2009; Miorandi et al., 2012). For instance, in a smart factory, diverse smart workpieces subsequently interact with diverse smart tools to identify and perform pending production tasks. If a certain work step needs to be performed or supported by an employee, workpieces and tools report an ad hoc-staffing requirement that must be met as quickly as possible to avoid production stops or interruptions. Thus, the scheduling and assignment of such employees are to be increasingly realized in 'real-time' or at least 'near-time'. Moreover, comparable accelerations are expected for training and development. While the concept of 'just-in-time training' has been discussed for a long time (e.g. Iannerelli, 2009), experts agree that just-in-time training will be furthered by the IoT in HRM. In particular, digital assistant services at smart things that employees use during their work are expected to deliver the necessary training measures in 'real-time' (*item # 29*). Again, this acceleration of training is perceived as necessary to avoid interruptions and delays in providing products and services to customers. In summary, this acceleration of service delivery in different HR activities constitutes a step towards making HRM an organizational real-time function (e.g. Haller & Magerkurth, 2011) that delivers the respective services immediately and without any delay. The reason for such a 'real-time HRM' is twofold: On the one hand, acceleration constitutes an advantage per se since the reaction time of HR and thus the waiting time for its customers are reduced. On the other hand, there are also clear needs due to the general digitalization of business to increase the speed of HR services. Acceleration, therefore, constitutes an excellent example of how the potential changes that the IoT entails for HRM are used to meet the requirements that the IoT poses for HRM. As introduced above, the corresponding phenomenon of change might be called *acceleration of HRM*.

A further interesting phenomenon of change refers to HR information. However, given that HR information constitutes a general 'support' activity, providing information for all other activities, the change again affects HRM *in toto*. First, experts expect the quantity of HR information to increase (*item # 13*), which is obviously based on the expectation that larger sets of sensors scattered across numerous smart things will allow the measurement of numerous new HR-related issues (e.g. Swan, 2012). Second, experts additionally expect the quality of HR information to increase (*item # 14*). This constitutes a particularly interesting finding, since sensors are obviously perceived to improve the measurement quality compared to conventional, non-sensor-based varieties of HR data-ascertainment. As discussed above, third, the timeliness of HR information will also increase due to a real-time measurement based on sensors (*item # 15*), ensuring very prompt information for HR stakeholders regarding relevant events. Corresponding with the increased quality, quantity and speed of HR information provision, the importance of providing HR information is also expected to increase (*item # 17*). In summary, experts predict the increased provision and utilization of information in HRM. Overlapping with the current discussion on HR analytics (e.g. Marler & Boudreau, 2017), this represents basing HR decisions and activities on information and evidence rather than on mere intuition and conjecture. Taken together, these predicted changes might be designated the *informatization of HRM.*

Beyond these general changes in HR activities, some detailed changes could also be identified. These refer, for instance, to the flexibilisation of employee working times (*item # 24*), the personalization of employee working environments (*item # 25*) or the improvement of employee performance (*item # 36*), among others (see Appendix).

In summary, experts expect the application of the IoT in HRM to induce diverse general and detailed changes in HR activities. The general changes, such as acceleration and informatization of HRM, particularly uncover that these transformations are expected to be noticeable. An interesting insight is that changes in HR activities result from new opportunities that the IoT offers for HRM; however, they also result from new requirements that the IoT imposes on HRM. This could be illustrated by the acceleration of HRM arising from both the new possibilities and the new requirements of the IoT. Aiming at the initial exploration of expectable changes, the insights obtained are, however, far from being a complete inventory of change.

4.4. HR actor results

The items on HR actors refer to the changes in the senior HR manager (*items # 43–47*), HR business partner (*items # 48–52*) and HR administrator positions (*items # 53–57*). Again, the aggregated results are visualized in a change diagram, and again, all actor categories are located in quadrant IV (see Figure 5).

As a precondition for investigating IoT-induced changes for different HR actors, which shares of tasks will be still performed by which general authorities is generally investigated. Regarding this, experts first clearly disagree that HR departments will perform more activities in the future (*item # 59*). Conversely, increasing shares are expected for employees (*item # 60*), line managers (*item # 61*) and service companies (*item # 62*). While this distribution of activities to different authorities is not a new phenomenon (e.g. Ulrich, 2007), it seems to be intensified by the IoT. As a likely consequence, HR departments will also lose organizational resources, importance and status, which might be called *marginalization of the HR*

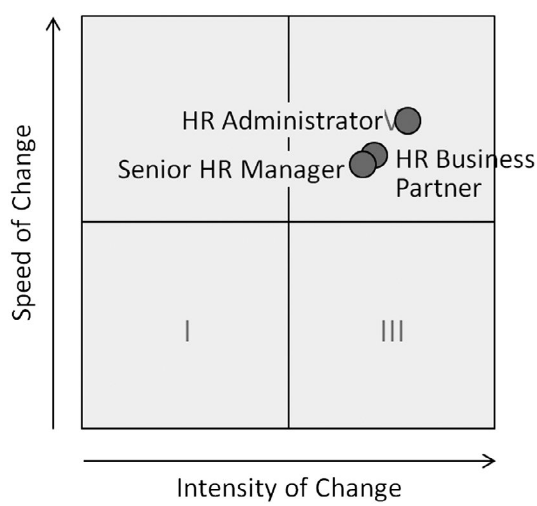

Figure 5. Changes in HR actors.

department. Two important sub-phenomena are noteworthy: The first refers to an increasing reliance on HR service companies (*item # 62*). This might be explainable by a lack of necessary technical expertise in the HR departments and might be called *reinforcement of HR technology outsourcing*. The second sub-phenomenon refers to increasing realization of employee self-service (*item # 60*). As exemplarily demonstrated by user training (*item # 29*), smart things are able to expand the HR tasks that employees can perform in a self-service manner, and experts predict these potentials to be utilized. This could be called the *reinforcement of employee self-service*.

Switching to internal HR actors, the first expected yet noteworthy phenomenon refers to the digitalization of HR positions (*items # 44–46, 49–51* and *54–56*). This can be exemplified based on senior HR managers. There is clear agreement that the share of digital tasks of senior HR managers will increase due to the IoT (*item # 44*). Correspondingly, it is also clearly agreed that senior HR managers will be confronted with increased digital qualification requirements to handle these tasks (*item # 45*). On the one hand, this rests on the expected change in digital HR technologies – as expressed by the changes in HR hardware, software and data. However, this also rests on the fact that work becomes digital *in toto,* and thus, future efforts in recruiting, staffing, training, etc. require a deep understanding of this digitalization to be successful. Third, it is also expected that senior HR managers will receive increased digital support from future IoT technologies (*item # 46*). This indicates that the changes in HR technologies, as elaborated above, are expected to have productive consequences for HR professionals. The 'trias of digitalization' comprising increased digital tasks, increased digital qualification requirements and increased digital support also applies in parallel for HR business partners (*items # 49–51)* and for HR administrators (*items # 54–56*). While not unexpected, the clarity and definiteness of the predicted changes are remarkable. The overarching phenomenon of change might thus be termed the *digitalization of the HR profession*.

Corresponding with this, some experts expect the emergence of *new hybrid HR actors* at the intersection of HR and IT, i.e. a 'Chief Digital HR Officer', and suggested a corresponding item for the second round. This change narrowly failed the necessary agreement rate (*item # 72*), and experts do not expect such hybrid actors.

Moreover, given the potential to automate further HR tasks, the question arises if this leads to an obsolescence of certain HR actors. Regarding the reduction in HR positions, there is a clear agreement for HR administrators (*item # 53*), indecisiveness (but not polarization) regarding HR business partners (*item # 48*) and a disagreement regarding senior HR managers (*item # 43*). Obviously, the expected automation effects of the IoT will decrease on higher hierarchical levels. The change can be designated *level-dependent automation of HR positions*.

In summary, the experts expect noticeable IoT-based changes for HR departments in general and for HR actors in particular. Again, the experts expect these changes to occur over a period of 5 years. In particular, the phenomena of a triple digitalization of HR positions uncovers the fact that smart HR does not constitute a niche topic relevant only for some technical specialists in the IT department but is of broader relevance for the entire HR profession.

5. Conclusions – results, limitations and implications of the study

5.1. Results of the study

The current paper aimed at an initial exploration of the future application and consequences of the IoT in HRM. Using a Delphi approach yielded interesting insights. Regarding the first research question, the *application of the IoT in HRM* (and thus the *realization of Smart HRM*) is perceived as a likely development in the near future. This is substantiated by the expectation of a future application of smart things and sensors in HRM, as well as the expectation of further phenomena as outlined above. Moreover, regarding the second research question, diverse notable *consequences of the IoT in HRM* are predicted. They initially and necessarily refer to HR technologies: Adopting smart things and sensors will change hardware, software and data in HR as outlined above. Second, the changes also involve larger modifications of HR activities, but they will obviously be asymmetrically affected by the IoT, as uncovered by the phenomenon of dichotomization in HRM. Further overarching changes, such as the acceleration and informatization of HRM, can be directly traced back to the IoT. Interestingly, several changes were both enabled *and* required by the application of the IoT in organizations, as could be uncovered, for example, in the acceleration of HRM. Third, the application of the IoT is also expected to noticeably change the tasks and qualifications of HR actors.

While these results offer initial interesting insights, clearly indicating smart HRM to constitute both a likely and a relevant future development, it also becomes clear that the application and consequences of the IoT in HRM are far from being sufficiently researched.

5.2. Limitations of the study

A first and basic limitation of the study lies in the employed research method. Regarding the future application and consequences of the IoT in HRM, a Delphi study can provide an educated guess on these questions and a justifiable basis for their future discussion. It cannot, of course, guarantee that all predicted changes will occur exactly as predicted – as with any other prognostic approach (e.g. Hasson & Keeney, 2011). Moreover, as a second limitation, the employed framework considers HR technologies, activities and actors as relevant configurational components, and thus, it is very broad in scope. Therefore, changes could only be considered in a general manner (e.g. it was only ascertained that the digital tasks of HR actors would increase, while the concretes type of tasks were not ascertained), while some changes were not considered at all (e.g. changes for actor groups outside the HR department were excluded for reasons of scope). As a third limitation, the study aims at descriptive insights on the future application and consequences of the IoT in HRM. Thus, the study lacks broader prescriptive insights on how to apply the IoT and how to cope with the desired and undesired consequences of the IoT. Finally, a fourth limitation results from the national and sectoral focus of the study. All experts were from Germany and were – practically or academically – involved with smart manufacturing. Since there are no insights thus far on cross-national and cross-sectoral similarities or differences in the IoT in HRM, the results of the study are restricted to the German smart manufacturing context.

5.3. Implications of the study

Due to both the opportunities and threats involved, the IoT will likely gain relevance for HRM. To support the future exploitation of opportunities and the limitation of threats, the research on the IoT in HRM should not await practical developments and research them *ex post facto* but instead aim at accompanying and even guiding practical developments. To realize such a research program in smart HRM, the major research approaches are design research and empirical research.

As a first research approach in smart HRM, *design research* should aim at a better exploitation of the potentials of smart HRM in practice. Beyond design research (e.g. Hevner, March, Park, & Ram, 2004), related ideas such as action research (e.g. Baskerville, 1999) also constitute suitable approaches. A prominent starting point is the development of smart HRM use cases (e.g. Bittner & Spence, 2002). A smart HRM use case refers to a concrete application scenario of the IoT in HRM. Developing a use case thus implies the conceptualization and evaluation of the relevant technical and managerial aspects of a specific application idea. Examples of already elaborated use cases are sensor-based employee stress-management (e.g. Kocielnik, Sidorova, Maggi, Ouwerkerk, & Westerink, 2013) or smart things-based employee training (e.g. Charmonman et al., 2015). In this way, further use cases of employing sensors and/or smart things to improve HR information and automation are a promising avenue. As a complementation and concretization of use cases, a prototypical realization of related *artefacts* constitutes a further useful objective of design research (e.g. March & Smith, 1995). A core artefact category, of course, refers to prototypical software that illustrates how a smart HRM use case can be realized. However, methods, constructs or models related to the use case also constitute relevant artefacts (e.g. March & Smith, 1995). An example of an already elaborated artefact that substantiates a use case refers to smart workforce scheduling software (Spath et al., 2013). A systematic use case and artefact development throughout the different HR activities will not only support practice by providing concrete suggestions for realizing smart HRM but will also validate the overall potentials and limitations of applying the

IoT in HRM. Therefore, smart HRM implies a rich source of design research opportunities and necessities.

As a second research approach in smart HRM, *empirical research* should aim at creating knowledge of the actual application and the actual consequences of smart HRM. Researching the actual *application* of smart HRM refers to multiple adoption-related issues, such as the drivers, inhibitors, rate, speed, sectors and activities of adoption (e.g. Rogers, 2010; Venkatesh, Morris, Davis, & Davis, 2003). Drivers and inhibitors refer to the technical, managerial and/or social forces that further or prevent an application of the IoT in HRM. A managerial driver, for instance, might be an expected massive expansion of information quality and quantity, as predicted by this study (e.g. Waber, 2013), while as the other side of the same coin, a social inhibitor might be an expected total surveillance of employees (e.g. Weston, 2015). The rate and speed of adoption refer to identifying how intensively and how fast the IoT actually diffuses in HRM. Sectors and activities refer to identifying potential sectoral adoption differences and, as predicted by this study, activity-related adoption differences. Researching the *actual consequences* of smart HRM refers to technical, managerial and social results. For instance, a technical consequence might refer to an increased technical vulnerability of HRM, as sensors and smart things can be attacked via the Internet (e.g. Zhao & Ge, 2013), while a managerial consequence might be a massive informatization of HRM, as predicted by this study, and a social consequence might be a loss of administrative HR positions, as again predicted by this study. Empirical research into the consequences, however, is currently noticeably restricted by the nascent state of smart HRM. This implies an application of empirical methods that are not reliant on a broader adoption of smart HRM in practice. For instance, experiments can be used to empirically research adoption-related aspects, such as the acceptance of wearable sensors by employees (e.g. Weston, 2015). Moreover, case studies in pioneering organizations that have implemented (certain facets of) smart HRM can be used to gain qualitative insights into the consequences of the IoT in HRM. If the adoption of smart HRM progresses, further empirical methods, such as surveys, can also be employed. Therefore, smart HRM implies a rich source of empirical research opportunities and necessities.

In summary, according to the results of the current study, smart HRM constitutes a likely and relevant future development. It offers ample research prospects for both design-oriented and empirical research. This means that HRM scholars now have the chance to accompany and co-shape this interesting new development.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix 1. Items and results of the Delphi study

Legend:

unweighted – no weights for self-rated competence levels
weighted – 0-1-2-3 weights for self-rated competence levels
M – mean
SD – standard deviation
DAR – disagreement rate (proportion of fully disagreeing or rather disagreeing experts)
AR – agreement rate (proportion of fully agreeing or rather agreeing experts)
(1)significant differences between HR management practitioner, HR management researcher, HR technology practitioner and HR technology researcher experts
(2)significant differences between practitioner and researcher experts
(3)significant differences between HR management and HR technology experts

			Unweighted				Weighted			
	#	*Items 'HR Technologies'*	M	SD	DAR	AR	M	SD	DAR	AR
HR Hardware	1.	*HRM will employ smart things for HR purposes*	4.14	0.95	0.05	0.73	4.32	0.88	0.05	0.83
	2.	*HRM will employ sensors for ascertaining HR data*	4.08	0.86	0.03	0.73	4.14	0.86	0.03	0.76
	3.	*In which time horizon will the above changes occur?*	2.27	0.65	–	–	2.19	0.62	–	–
HR Software	4.	*HR software will interact with smart things and sensors(2)*	3.38	0.95	0.19	0.51	3.48	0.91	0.16	0.56
	5.	*HR software will interact with software that interacts with smart things and sensors(1) (2)*	3.76	0.86	0.14	0.76	3.86	0.80	0.10	0.79
	6.	*HR software will provide services in near-/real-time (1) (3)*	4.30	0.91	0.05	0.81	4.41	0.84	0.03	0.84
	7.	*In which time horizon will the above changes occur?*	2.51	0.65	–	–	2.48	0.62	–	–
HR Data	8.	*HR data will stem from sensors on smart things that employees use*	3.49	1.04	0.14	0.59	3.56	1.04	0.14	0.62
	9.	*HR data will stem from sensors that employees wear ('wearables')*	3.35	0.92	0.19	0.51	3.37	0.97	0.21	0.52
	10.	*HR data will show high volume, variety and velocity ('big data')*	4.05	0.74	0.03	0.81	4.13	0.75	0.03	0.84
	11.	*HR data will be more reliable and objective(3)*	3.19	0.94	0.19	0.38	3.24	0.89	0.17	0.38
	12.	*In which time horizon will the above changes occur?*	2.38	0.68	–	–	2.41	0.69	–	–
		Items 'HR Activities'								
HR Information	13.	*The quantity of HR information will increase(3)*	4.32	0.75	0.03	0.89	4.36	0.72	0.01	0.89
	14.	*The quality of HR information will increase*	3.62	0.95	0.14	0.65	3.64	0.97	0.11	0.64
	15.	*The latency of HR information will decrease*	3.76	0.60	0	0.68	3.78	0.61	0	0.68
	16.	*The digitalization of HR information will increase*	2.27	0.77	0.03	0.95	4.22	0.84	0.04	0.94
	17.	*HR information will become more important*	3.76	1.09	0.14	0.62	3.78	1.09	0.13	0.65
	18.	*In which time horizon will the above changes occur?*	2.03	0.50	–	–	2.03	0.53	–	–

(*Continued*)

Appendix 1. (*Continued*)

	#		Unweighted				Weighted			
			M	SD	DAR	AR	M	SD	DAR	AR
HR Recruiting	19.	*HR recruiting requirements will be determined by smart things*	2.84	0.93	0.41	0.30	2.82	0.97	0.40	0.31
	20.	*HR selection will be supported by smart things*	3.00	1.18	0.41	0.46	3.00	1.18	0.39	0.47
	21.	*HR recruiting will become more important*(3)	3.81	1.13	0.16	0.68	3.90	1.14	0.14	0.71
	22.	*In which time horizon will the above changes occur?*(3)	2.41	1.17	–	–	2.38	1.16	–	–
HR Staffing	23.	*Employee scheduling and assignment will be performed in near-/real-time*(3)	3.78	0.85	0.11	0.73	3.86	0.84	0.10	0.76
	24.	*Real-time requirements will induce flexible working times*(3)	4.00	0.78	0.03	0.76	4.06	0.80	0.03	0.76
	25.	*Smart things enable an assignment appropria-te to the health, age and handicap of employees*	3.60	1.07	0.19	0.62	3.69	1.10	0.17	0.67
	26.	*HR staffing will become more important*(1) (2) (3)	3.73	0.87	0.08	0.62	3.86	0.83	0.04	0.67
	27.	*In which time horizon will the above changes occur?*	2.32	0.58	–	–	2.32	0.58	–	–
HR Development	28.	*Employee training information (qualifications, success, etc.) will be provided by smart things*(2)	3.24	0.83	0.22	0.43	3.29	0.80	0.18	0.44
	29.	*Digital training services with smart things will allow for a just-in-time training of employees*(1)	3.97	0.96	0.11	0.76	4.04	0.91	0.08	0.78
	30.	*Smart work will induce a polarization of qualifications*	3.51	1.15	0.24	0.49	3.57	1.11	0.21	0.5
	31.	*HR development will become more important*	4.03	0.90	0.05	0.73	4.08	0.84	0.03	0.75
	32.	*In which time horizon will the above changes occur?*(2)	2.41	0.80	–	–	2.40	0.73	–	–
HR Performance	33.	Employee objectives will be determined by smart things	2.76	0.93	0.46	0.27	2.75	0.98	0.46	0.29
	34.	Employee appraisal will be based on sensor data	2.60	0.93	0.57	0.19	2.65	0.95	0.51	0.21
	35.	Smart things will improve individual performance	3.49	0.84	0.14	0.54	3.56	0.82	0.11	0.57
	36.	Performance management will become more important	3.54	0.73	0.05	0.59	3.60	0.66	0.04	0.63
	37.	In which time horizon will the above changes occur?	2.54	0.73	–	–	2.50	0.67	–	–

(*Continued*)

Appendix 1. (*Continued*)

	#		Unweighted				Weighted			
			M	SD	DAR	AR	M	SD	DAR	AR
HR Compensation	38.	Sensors will deliver compensation information	3.00	0.82	0.32	0.32	3.13	0.80	0.26	0.39
	39.	Smart work will polarize compensation	3.00	0.94	0.38	0.32	3.08	0.98	0.35	0.35
	40.	Employee compensation will become flexible and individualized(3)	3.05	0.91	0.24	0.32	3.10	0.94	0.22	0.36
	41.	The importance of compensation will increase	2.87	0.92	0.38	0.21	3.00	0.93	0.32	0.25
	42.	In which time horizon will the above changes occur?	2.76	0.86	–	–	2.74	0.86	–	–
		Items 'HR Actors'								
Senior HR Manger	43.	Senior HR manager positions will be reduced	2.60	0.99	0.59	0.19	2.58	1.01	0.60	0.18
	44.	Senior HR manager positions will show an increased share of digital tasks	4.05	0.66	0.03	0.86	4.09	0.63	0.01	0.87
	45.	Senior HR manager positions will require increased digital qualifications	4.22	0.67	0.03	0.92	4.25	0.63	0.01	0.92
	46.	Senior HR management positions will receive increased digital (decision) support(3)	4.19	0.85	0.05	0.84	4.18	0.88	0.08	0.84
	47.	In which time horizon will the above changes occur?	2.24	0.83	–	–	2.17	0.77	–	–
HR Business Partner	48.	HR business partner positions will be reduced (1)	2.89	0.97	0.41	0.27	2.84	0.93	0.42	0.23
	49.	HR business partner positions will show an increased share of digital tasks	4.05	0.74	0.05	0.86	4.07	0.78	0.06	0.86
	50.	HR business partner positions will require increasing digital qualifications	4.08	0.80	0.05	0.84	4.13	0.77	0.04	0.84
	51.	HR business partner positions will receive increasing digital counselling support	4.24	0.68	0.03	0.92	4.30	0.65	0.01	0.92
	52.	In which time horizon will the above changes occur? (1)	2.14	0.75	–	–	2.07	0.70	–	–
HR Administrator	53.	HR administrator positions will be reduced	3.92	0.89	0.11	0.78	4.00	0.84	0.08	0.81
	54.	HR administrator positions will show an increased share of digital tasks	4.11	0.74	0.05	0.89	4.16	0.75	0.05	0.90
	55.	HR administrator positions will require increased digital qualifications	4.19	0.97	0.08	0.86	4.21	1.00	0.08	0.86
	56.	HR administrator positions will receive increased digital administration support	4.51	0.69	0.03	0.95	4.60	0.61	0.01	0.96
	57.	In which time horizon will the above changes occur? (1)	1.92	0.83	–	–	1.84	0.76	–	–

(*Continued*)

Appendix 1. (*Continued*)

	#		Unweighted M	SD	DAR	AR	Weighted M	SD	DAR	AR
General HR Actors	58.	IoT technology will increasingly perform HR tasks	3.19	0.81	0.19	0.32	3.21	0.80	0.17	0.31
	59.	HR departments will increasingly perform HR tasks [3]	2.38	1.06	0.59	0.16	2.38	1.10	0.60	0.17
	60.	Employees will increasingly perform HR tasks [1] [3]	4.22	0.82	0.03	0.81	4.26	0.82	0.03	0.82
	61.	Line managers will increasingly perform HR tasks [1] [3]	4.22	0.79	0.03	0.84	4.26	0.80	0.03	0.83
	62.	HR service companies will increasingly perform HR tasks [1]	3.54	0.99	0.19	0.65	3.55	0.99	0.17	0.64
	63.	Works councils will be crucial for realizing smart HRM	4.22	1.11	0.14	0.76	4.20	1.17	0.17	0.74
	64.	In which time horizon will the above changes occur?	2.00	0.67	–	–	1.95	0.71	–	–
		Items 'HR Awareness and State'								
	65.	HRM has recognized the IoT as a relevant development[1] [3]	2.43	1.02	0.54	0.14	2.55	1.03	0.51	0.17
	66.	HRM is able to cope with the requirements of the IoT[1] [3]	2.19	0.62	0.70	0	2.22	0.62	0.68	0
	67.	HRM has an active and leading role in organizational IoT implementation [1] [3]	1.84	0.83	0.84	0.05	1.86	0.87	0.82	0.06
		Further Items from Experts in Round 1								
	68.	HRM will use mobile devices for interaction with smart things [1] [3]	4.00	0.76	0.03	0.79	–	–	–	–
	69.	HR software/hardware will implement 'privacy by design'	4.14	0.79	0.03	0.83	–	–	–	–
	70.	Privacy and codetermination legislation constitute barriers for smart HRM	4.17	0.97	0.10	0.83	–	–	–	–
	71.	Sensor data will be used for individual behaviour analysis and prognosis of employees	2.79	0.86	0.38	0.17	–	–	–	–
	72.	Hybrid positions at the intersection of technology and HRM will emerge (e.g., 'Chief Digital HR Officer')	3.24	0.87	0.21	0.48	–	–	–	–
	73.	Occupational safety will improve due to smart things	4.07	0.75	0.03	0.83	–	–	–	–
	74.	Sensor data will be used for analysing the psychological stress of employees[1]	3.00	1.17	0.38	0.41	–	–	–	–