A Socio-Technical Approach to Manage Analytics-as-a-Service – Results of an Action Design Research Project

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Abstract. The ability to generate business-relevant information and its use for business process improvements is a key success factor for businesses today. Answering the call for further research on success-relevant practices and instruments for managing business analytics, we report on the results of a three-year action design research project at a global car manufacturer. Drawing on the socio-technical systems theory, we identify seven meta-requirements and specify four principles for the design of an instrument to manage Analytics-as-a-Service (Aaas) portfolios. Our results reinforce the importance of coordinating different socio-technical components in business analytics initiatives and demonstrate how concrete management instruments, such as the proposed portfolio management tool, contribute to socio-technical alignment. For practitioners, the documented design components may provide guidance on how to design and implement similar instruments that support the management of Aaas portfolios.

Keywords: analytics-as-a-service, action design research, big data analytics, business analytics, governance.

1 Introduction

The ability to generate business-relevant information and exploit it to improve business processes is a key success factor for businesses today in facing the digital transformation [1]. Even in industries with commodity products and highly standardized services, business analytics offers companies the opportunity to generate new competitive advantages [2]. The possibilities for use are diverse and range across the individual functional areas of a company (e.g., supply chain, pricing, marketing, product quality, research, and development) with companies such as Amazon or Google to established companies such as Wal-Mart or Novartis, who successfully use analytics to their advantage [2]. Although the trend towards leveraging data to improve decision-making is not entirely new, the technological pervasion through digital technologies such as sensors or personal digital devices (e.g., smartphones and tablets) and the ability to store and analyze data in real-time through innovative technologies led to the emergence of the phenomenon of big data analytics [1]. In order to leverage this disruptive potential and to bundle analytics competencies, larger companies increasingly adopt shared service models and offer Analytics-as-a-Service (AaaS) to

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business units [3]. However, most traditional companies are unable to generate business value through analytics projects and AaaS offerings, because they fail to address the associated structural, skill-specific, technology-oriented, and business process-oriented challenges stemming from the socio-technical nature of business analytics [4–6]. More precisely, the process of value creation through analytics requires an active and collaborative sense-making process of organizational participants (e.g., analysts and business managers) within the boundaries of the organizational socio-technical work system [7, 8]. Consequently, the management of AaaS not only involves the management of business demands and service requirements but requires an active management of service prototypes and implementations. Such activities are typically handled by a portfolio management function supported by specific management tools or instruments (most particularly a portfolio management tool) [9, 10]. Despite the growing body of practitioner reports [1, 5] as well as of academic literature [11, 12], research on how to exploit analytics to the advantage of companies is still scarce [11, 13] . With our research we address the lack of academic knowledge on portfolio management for AaaS by identifying principles for the design of a portfolio management tool. Accordingly, we pose the following research question: *"How to design a portfolio management tool to support the systematic management of AaaS?"*

We report on the results of a three-year action design research project, which was started at the beginning of 2015. This project aimed at developing a single point of truth for all analytics services to manage analytics services according to the priorizations of the central analytics unit's customers of the organization *CarCo*. At the beginning of our project all services were managed and coordinated with manual documentation on a printed excel spread sheet. Due to the increasing complexities the central analytics unit faced the underlying manual tasks were not feasible anymore and slowed down the day to day work of the central analytics unit. During this project, we used several academic approaches to tackle our phenomenon of interest (e.g., focus group workshops, semi-structured interviews, and observations).

Our work provides two key contributions. First, this work specifies requirements and design propositions for designing an AaaS portfolio management tool and thus addresses the need to further consider "socio-technical and socio-material design considerations for algorithmic decision systems" [14]. Second, this paper contributes rich empirical insights on the (up to this date underexplored) success factors of managing AaaS and responds to calls for further research in this area [11, 14–16].

2 Theoretical Foundations

2.1 A Socio-Technical Systems Perspective on Business Analytics

The socio-technical systems (STS) theory offers a multivariate system perspective on information systems that consists of four interrelated system components and allows its analysis [17, 18]. The social subsystem comprises *structures* and *actors*, whereas the technical subsystem comprises the *technology* and a *task* component [17, 18]. Actors are, amongst others, characterized by employees' capabilities and qualifications as well as a shared culture, structures by project organizations and institutional arrangements, technology by tools and technological platforms, and tasks by the required processes to fulfill work or the delivery of services [17–19].

Following Chen et al. [12] and Holsapple et al. [20] we use business analytics as an umbrella term encompassing the term big data analytics. Business analytics can be understood as a socio-technical phenomenon affecting organizations in multiple ways [20, 21]. Accordingly, to conceptualize analytics from a STS-perspective, (1) the technical system and (2) the social system have to be differentiated. First, the implementation of analytics technology, such as Hadoop cluster and hive (*technology*) is required to provide the technological basis to improve e.g., decision-making processes, and to achieve product, and service innovation (*task*) [1, 22, 23]. Second, in regard to the social system, *actors* require applied skills in the areas and intersections of technology, analytics, and business, others a general knowledge about big data analytics to successfully lead, manage, and implement big data initiatives [24]. Further, an organization needs to transform its organizational *structures* such that they support and establish cross-departmental collaboration [2, 4]. Therefore, we regard analytics as a strategic capability to gain analytical insights from (big) data which equally resides in technological and organizational system components.

In IS research STS theory proved to be useful to elaborate IS induced changes in the organizational context by taking interrelationships between social and technical system components into account [19]. The interactions between the social and technical systems are inherently recursive, that is "users shape the technology structure that shapes their use" [25]. The recursive use of technology in the organizational context results in "enacted structures of technology use" and "while users can and do use technologies as they were designed, they also can and do circumvent inscribed ways of using the technologies" [25]. Thus, knowledge about the alignment of socio-technical components is of critical importance, because information systems are continuously challenged by incremental and punctuated changes to one or more of its system components [19].

This view has general implications for the development of a tool to manage and govern an AaaS portfolio: Before successfully exploiting a technology innovation such as analytics, a multitude of organizational transformations is necessary (e.g., cultural and structural change). Thus, when designing tool to manage and govern an AaaS portfolio the "enacted structures of technology use" [25], which might result from the recursive interaction with analytics services, need to be taken into account. Therefore, to realize the potential advantage of AaaS, organizations need to analyze and understand how they can use and manage data analytics and require associated management instruments. Following the call of Abbasi et al. [15] for further research on data analytics and big data, we use "action design research (ADR) to guide the development and harnessing of big data IT artifacts [in a real-world] organizational [setting]" [15]. In particular, we focus on designing and implementing an instrument to manage the AaaS portfolio at the central analytics unit of a leading car manufacturer using the socio-technical systems theory as reference theory.

2.2 Portfolio Management

In the following, we relate our study to portfolio management, in general, and to project portfolio and service portfolio management, in particular, as these adjacent research fields inform our design of the portfolio management tool for AaaS. The original concept of portfolio management was coined by Markowitz [26]. Portfolio management in its original sense targeted the financial domain to decide on investments portfolios. Over the years, portfolio management was used to manage new product development [27], new service development [28], project management [29–31], and IT service management [32–34]. Extant literature on portfolio management [27, 29, 31] outlines several key objectives of portfolio management: maximization of value (i.e., value maximization of the portfolio against business objectives), balance of the portfolio (i.e., managing the risk of the portfolio), and strategic alignment (i.e., alignment of the portfolio with the overall strategy). Literature on project portfolio management further details these objectives into "(1) defining goals and objectives, i.e., clearly articulating what the portfolio is expected to achieve, (2) understanding, accepting, and making trade-offs, (3) identifying, eliminating, minimizing and diversifying risk, (4) monitoring portfolio performance, i.e., understanding the progress that portfolio is making towards the achievement of the goals and objectives, and (5) establishing confidence in achieving a desired objective" [30]. In targeting the systematic portfolio management of AaaS, we understand service portfolio management "as a dynamic decision-making process that is dedicated to the continuous, strategically aligned revision of service portfolios" [33]. Thereby, several portfolio management models can be distinguished, e.g., financial models, scoring models and checklists, mapping approaches, or mathematical optimization procedures [27]. To achieve this, the portfolio management is widely supported by a dedicated portfolio management tool [28, 30]. Accordingly, the ultimate goal of this research endeavor is the provision of a corresponding portfolio management tool for AaaS.

In summary, the literature provides valuable insights into project and portfolio management related to the definition of projects and of goals, minimization of goals as well as the confidence in these goals [30]. However, due to the socio-technical nature of analytics the realization of the potential business value from analytics, socio-technical configurations, amongst others related to a data-oriented practices, structures, technologies, and analytical processes need to be taken into account when pursuing analytics projects and developing a portfolio management tool for AaaS [7, 8]. For this reason, previous approaches are not applicable in this context without adapting or extending these approaches.

3 Research Approach

We conduct action design research (ADR) with the goal to obtain relevant results by means of a rigorous yet pragmatic approach due to its suitability for addressing practice-inspired research problems [35, 36]. By drawing on the existing body of knowledge and by guiding the artifact building and evaluation phases, ADR supports the development of prescriptive design knowledge. ADR aims at generating solutions that apply not only to a problem instance but to a class of problems [36]. We embedded the 3-year ADR project in a collaborative practice-oriented research initiative [37] and followed Sein et al.'s [36] methodological guidelines (e.g., practice-inspired research, theory-ingrained artifact, and reciprocal shaping) (see Figure 1).

At the outset, we founded a collaborative research initiative with *CarCo*, a leading innovative original equipment manufacturer in the automotive industry who was on the edge of launching an AaaS initiative. *CarCo* is a multinational car manufacturer who targets customers in the premium segment and is known for their technological advancement and produces around 2 million cars a year making a profit of around €4 billion and employing around 90000 people world-wide. Particularly, we collaborated with several members of the central analytics unit at *CarCo* (among others the Head of Data Strategy and Analytics), who represent the targeted users of our artifact - in our case the portfolio management tool. We discussed and evaluated preliminary results in the build phase of the ADR project with practitioner experts. Thereafter, the prototype was iteratively built, evaluated, and refined with the targeted users, i.e., the Head of Data Strategy and Analytics, and stakeholders, i.e., the Head of Analytics Services.

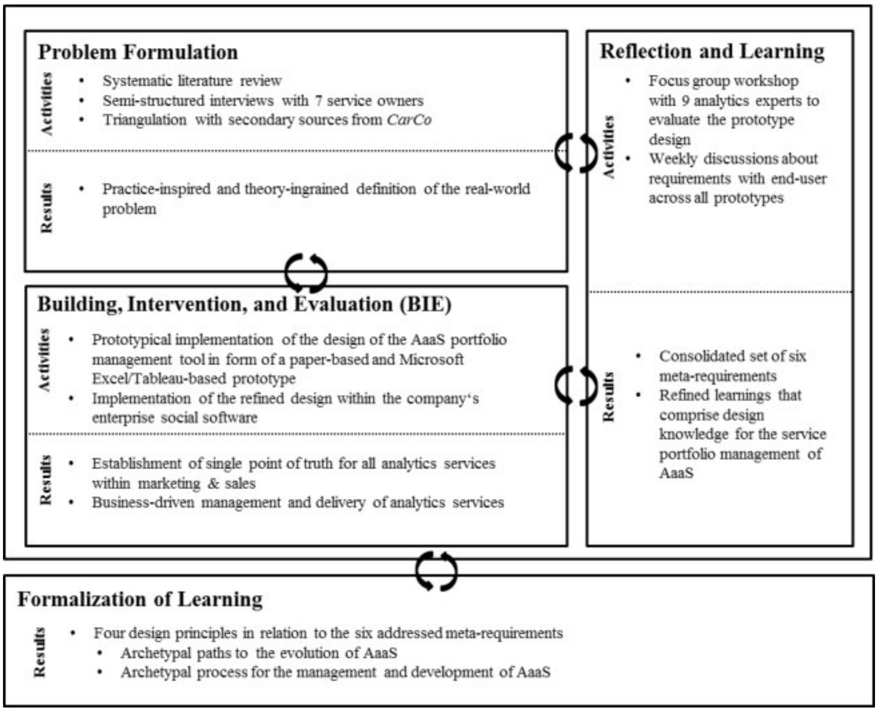

Figure 1. Overview of ADR stages with Key Activities and Results [36]

Following the ADR methodology and particularly Sein et al.'s [36] principle of 'guided emergence', meta-requirements (MR) emerged from the reflection on and learning from the problem formulation phase. In the subsequent building, intervention and evaluation phases, a solution design was iteratively refined in a three-cycle design process. The concurrent reflection on the design in our real-life application context resulted in learnings that comprise generalized design knowledge for the service portfolio management of AaaS to address not only a problem instance but also a class of problems [38]. Thus, we elicit MRs that apply to the problem class that the ADR project aims to address (i.e. AaaS portfolio management). To do so, we follow the two key principles of Sein et al. [36]: (1) practice-inspired research and (2) theory-ingrained artifact. To elicit MRs, we use triangulation and rely on rich data from both (1) a systematic literature review and (2) data obtained from a focus group workshop with domain experts, and multiple bilateral interviews with targeted end-users (i.e., Head of Data Analytics & Strategy). Finally, these learnings were formalized as generic design principles (DP) addressing the identified MRs to generate prescriptive design knowledge.

Problem Formulation. First, to identify potentially relevant related work, we conducted a literature search following the guidelines of Webster and Watson [39]. We were interested in identifying prior business analytics portfolio management approaches, following Sein et al.'s [36] principle of drawing on prior theory ("Principle 2: Theory-Ingrained Artifact"). We broadly searched the literature base for articles addressing the management of business analytics and analytics services. As keywords, we used the terms: "business intelligence" and "analytics" in combination with the more general terms "service" and "portfolio management" to query the databases "EBSCO Host Business Source Complete", "ProQuest", and "AIS library" resulting in 22 hits for "analytics" and 9 hits for "business intelligence".

We, initially, screened all articles in detail to sort out irrelevant articles. However, we were not able to identify reusable concepts for our phenomenon of interest (i.e., the management of an AaaS portfolio) in the current body of literature. As a consequence, we turned to more general theories on business analytics, its antecedents and contextual factors and portfolio management in general. In particular, we turned to IT service management [32–34], project portfolio management [29–31], and product portfolio management [27]. Since business analytics represents a socio-technical phenomenon that affects organizations in multiple dimensions (e.g., in regard to culture, organizational structures, work processes, capabilities, or, ultimately, business models) [1, 21, 23, 40] and to follow the principle of a "theory-ingrained artifact" [36], our research is informed by the socio-technical systems (STS) theory. In doing so, we are able to increase rigor within the problem formulation phase of our action design research project. Drawing on these foundations we conducted interviews with seven service owners, which were responsible for the management and development of seven analytics services within the AaaS initiative. We collected meta-requirements in the four STS-dimensions and used Atlas.ti for analyzing and coding interview notes. Third, secondary data that had been provided either by the interviewees or the manager in charge of the AaaS initiative further augmented our empirical data. As a result of data triangulation, we derived MRs and refined them in a focus group workshop with nine experts on business analytics to pursue the process of ex-ante evaluation of our prescriptive design knowledge [41]. These experts were a Performance and Improvement Manager as well as a Product Manager Business Intelligence from the agriculture industry, a Head of Digital Market Intelligence from market research industry, a Product Manager Business Intelligence & Data Science as well as a Chief

Executive Officer of an analytics advisory from retail industry, a Head of Digital Marketing from lightning industry, a Product Manager Data Management as well as a Product Manager Business Intelligence from the fast moving consumer goods industry, and a Professor for Digital Business. To do so, a paper-based prototype consisting of 15 data fields each corresponding to our initial set of MRs was explained to the participant of focus group workshop. In a next step, the participants gave formal feedback through a handout as well as informal feedback in case further explanations were needed.

Building, Intervention, and Evaluation (BIE). We performed an ex-post naturalistic evaluation drawing on interviews and observations as evaluation methods [41, 42]. To do so, the identified MRs were addressed in a first cycle by means of a prototypical paper-based implementation. We applied and refined at *CarCo's* analytics unit based on multiple user feedback cycles with the Head of Data Analytics & Strategy. In a second cycle a prototypical portfolio management tool was designed using Excel's functionality to not only store data but also to create user interfaces and manipulate data through its programming language Visual Basic for Applications and Tableau as visualization software to make the artifact tangible for the end-users (managers of the central analytics unit and the product management of the AaaS initiative) allowing the evaluation of its practical use [41]. Thus, after this initial implementation of the management tool, it was evaluated and validated with the Head of Analytics Services during a two-hour meeting and with the Program Manager for the AaaS initiative [36] during an additional two-hour meeting. This resulted in the consolidation of our initial set of 15 meta-requirements to 6 MRs for the following reasons. First, our initial set of MRs did consider the service instance on a fine granular level, which increased the effort to maintain the service portfolio. Second, due to the feedback of the focus group workshop rather redundant fields were eliminated (e.g., "business problem" as it was perceived as too detailed and too redundant to the existing field "business value"). Acknowledging the consolidated set of 6 MRs, the tool was finally in a third cycle integrated into *CarCo's* enterprise social software (ESS) as part of the AaaS Atlassian Confluence Space of the central analytics unit. During this implementation, we constantly evaluated in face-to-face meetings our artifact with the Head of Data Analytics & Strategy, the Head of Analytics Services, and, primarily, the product owner of the analytics-as-a-service initiative by ensuring the practical use and foremost feasibility to maintain and sustain the artifact after our action design research project.

Formalization of Learning. To provide prescriptive design knowledge we derived design principles through three additional interviews representing market participants (i.e., Head of Artificial Intelligence and Machine Learning at *VehicleCo*, Head of Data Analytics at Marketing and Sales at *VehicleCo*, Managing Consultant Development of Analytics Services at *PremCo*), as well as one interview with the program manager of the AaaS initiative drawing on our previous research steps. *VehicleCo* and *PremCo* can be seen as the most important competitors to *CarCo* targeting the same customer segment and producing cars in a similar engineering quality. As a result of analyzing this interview data and reflecting the project results, we were able to identify four design principles that reflect core characteristics of the proposed instrument for AaaS portfolio management. We acknowledged during these interviews that not only *CarCo* but also

VehicleCo and *PremCo* follow an archetypal path for the initial development of AaaS and sourcing decision. Moreover, in a similar fashion depending on their sophistication in regard to technology (i.e., technological readiness), analytical expertise and analytical capabilities (i.e., analytical readiness), and domain knowledge three archetypal paths dominated how analytics services are managed through their classes of services (i.e., descriptive, predictive, and prescriptive analytics services).

4 Results

4.1 Problem Design and Problem Solution

In the following, we elaborate on the six meta-requirements, which are based on our theoretical foundation (i.e., STS theory) and result from the reflection on the problem formulation phase (see Table 1):

Table 1. Overview of Identified Meta-Requirements

ID	Description	STS Domain
MR1	The service description must include a definition of the analytics service in order to achieve a common understanding of each service's functionality and outcome.	Task
MR2	The business value of each analytics service needs to be described.	Structure
MR3	The artifact should allow maintaining the feasibility and costs of the analytics service.	Structure
MR4	The artifact should allow to maintain the roll-out status and plan depending on the real-world context and the level of granularity.	Task
MR5	Service owners from both the business side as well as the analytics experts should be identified for each analytics service instance.	Actor
MR6	The description of each analytics service should include the analytical type (i.e., descriptive, predictive, and prescriptive) and the analytical method.	Technology

MR1. Following the need for a structured service description for service portfolio management [33] in general and in particular for analytics projects [7], we formulate MR1 based on our empirical findings as follows: "The service description must include a definition of the analytics service in order to achieve a common understanding of each service's functionality and outcome." Addressing MR1, the data fields service name, service definition, and comment are included to ensure a unified understanding of each service. The service definition describes the service functions in a business-oriented manner and thus refers to the task dimension of the socio-technical system.

MR2. To fulfill one of the main purposes of portfolio management (i.e., strategic alignment) [27, 30, 31, 33] – in our case to strategically align analytics services with the overall strategy - and grounded in our empirical insights, we introduce MR2: "The business value of each analytics service needs to be described". In addition, knowledge about the inherent value of analytics projects plays a crucial role to communicate service innovation possibilities [7, 8]. Addressing MR2, each generic service of the service portfolio is mapped to its corresponding value driver (i.e., business value) and business area (e.g., marketing & sales) enabling a prioritization of services. A strict value-orientation allows to govern analytics services in accordance with business strategy and thus affects the structure dimension of the socio-technical system.

MR3. To allocate a company's resources, align the portfolio with an organization's capacity, and to avoid losing sight of the costs [30, 31, 34] and drawing on our empirical evidences MR3 is theorized as "The artifact should allow maintaining the feasibility and costs of the analytics service." In particular, as analytics projects are evolutionary in nature the continuous control of costs is key for the management of AaaS. Addressing MR3, an initial estimate of the cost, as well as the complexity of the implementation of the analytics service, is provided by the management instrument. This supports communication and work flows in the governance dimension of the social-technical system. The ability to track and manage feasibility of the analytics service is particularly important for the end-user of this artifact as the provision of analytics services is charged to of internal business customers.

MR4. Due to the diverse customers of the AaaS initiatives (i.e., different target groups as part of CarCo or external, such as dealers and importers of CarCo) different granularity levels of services and their current status need to be taking into account [32–34]. In particular, CarCo's dealers and importers are distributed across the globe and do not form part of CarCo's organization. Therefore, they also might use services from external partner more easily. In result, the marketing of the analytics services based on the conducted implementation activities and the rollout status is highly important. Therefore, MR4 is phrased as "the artifact should allow to maintain the roll-out status and plan depending on the real-world context and the level of granularity." Answering to MR4, the rollout status of each service instance is documented within the service inventory table. The rollout status describes conducted implementation activities and thus relates to the task dimension in the socio-technical system.

MR5. To align business and IT, to assure a clear allocation of responsibilities, and to achieve confidence in the service [30, 32, 33] as well as due to the cross-disciplinary nature of analytics [4] MR5 is theorized as "Service owners from both the business side as well as the analytics experts should be identified for each analytics service instance." In response to MR5, each service instance has one service owner from the business department at the demand-side (i.e., a business owner) and one service owner stemming from the analytics experts at the provider-side (i.e., analytics owner). The specification of service owners relates to the actor dimension in the socio-technical system.

MR6. Allowing the prioritization and management of services depending on their current class of service [32, 33] MR6 is phrased as follows: "The description of each analytics service should include the analytical type (i.e., descriptive, predictive, and prescriptive) and the analytical method." Guided by MR6, each service is mapped to the analytics type (i.e., descriptive, predictive, and prescriptive) and the analytics model (e.g., decision-tree). These descriptions of the technological underpinnings relate to the technology dimension in the socio-technical system.

Instantiation of the Problem Solution. The artifact itself comprises a service portfolio management tool aiming at representing the single point of truth for all analytics services within marketing and sales. For instance, the AaaS offering includes a service to analyze depending on CarCo's data the demographic distribution of potential leads to increase the lead conversion as well as to potentially achieve up-selling – in the case of CarCo to transfer a customer from one car model to a superior car model. As such it follows a similar goal as project portfolio management. Namely, a centralized view of all projects – in our case analytics services - in an organization. Following Cooper et al. [27] the service portfolio management tool is a portfolio management tool to map current analytics services according to their strategic prioritization and to index analytics services according to their current status. As a result, analytics services are maintained by the analytics unit in the service portfolio management tool and a customer-orientated delivery of analytics services to internal business customers can be achieved.

Figure 2. Extract of the Prototype (only non-confidential information visible)

The derived meta-requirements (see Table 1) are met through specific data fields, which are needed to describe an analytical service on a detailed level. Being initially implemented with a Tableau dashboard and an Excel spreadsheet using VBA for data entry (see Figure 2) the artifact was finally implemented within the space of the central analytics unit's enterprise social software (see Figure 3). In doing, so the final artifact was accessible for all relevant personnel, namely the product owners of each service. They were tasked with maintaining the key information of the artifact and were updated to any changes made regarding their services due the clear assignment through the field "responsible" leveraging the notification system of Atlassian Confluence.

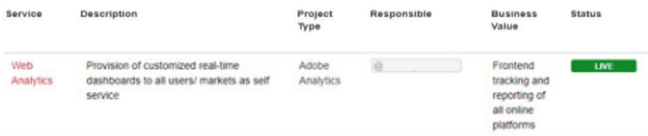

Figure 3. Extract Service Overview of the Live Version (only non-critical information visible)

4.2 Formalization of Learning

Contributing to the scientific body of knowledge on service portfolio management tools for AaaS, the design knowledge obtained within the ADR project is formalized in general design principles. These design principles represent learnings and generalized knowledge of the solution that was built within the course of the ADR project [36]. Table 2 provides an overview of the derived design principles and relates them to the addressed meta-requirements. They are further discussed in the following.

Table 2. Overview of Identified Design Principles [36]

ID	Design Principle	Addressed MRs	STS Domain
DP1	Maintain a taxonomy that guides the specification of business objectives of an AaaS offering in the portfolio management instrument.	MR1 MR2	Structure, Task
DP2	The demand-side business owner of an AaaS instance must be documented within the portfolio management instrument. Further, this business owner must be accepted by the supply-side.	MR3 MR5	Structure, Actors
DP3	For portfolio management to identify implementation status and to guarantee service quality, the portfolio management instrument must allow to assess how the implementation of each AaaS complies with a standardized archetypical development process.	MR3 MR4 MR6	Actor, Task
DP4	To ensure the successful implementation of AaaS, portfolio management instrument must allow the consideration of the trinity of technological readiness, analytical readiness, and business acumen.	MR3 MR5	Actor, Technology

DP1. The first design principle ensures sufficient visibility and budget for the development of AaaS offerings. Since in early project phases it is often non-trivial to define feasible and realistic business objectives, the maintaining of a taxonomy of AaaS business objectives and examples supports the specification of business objectives related to a planned or realized AaaS offering:

"You need the business case, you need the customer. Just to take data, to analyze it and to show the results is not enough. This approach often failed in the past because the business units just have no interest." Product Owner Analytics Services #1, CarCo, 2016

DP2. The second design principle targets a close collaboration of both the analytics experts (possibly part of business departments or IT department) and the requesting business units. A demand-side owner of the service instance should be specified for portfolio management. Further, this business owner should be accepted by the supply-side as a respected and qualified counterpart:

"The projects are always strong when a strong business unit is on board and that is something, we learn little by little in the projects. That means those topics that we started in a data-driven manner, and about which we had information only based on our available data, mostly did not make it far. But if we have someone from the demand-side, who is excited about the topic, and a business owner, who is familiar with the business problem, and combine this with analytical expertise, then it works." Head of Data Analytics & Strategy, CarCo, 2016

DP3. Relating to the third design principle**,** an archetypical process for the development of AaaS supports portfolio management in specifying implementation stage and in guaranteeing service quality: Triggered by a crisp and clear project idea in mind, the phase of exploration starts. Within this phase, the strategic relevance of the corresponding idea is assessed together with the internal feasibility (i.e., it is assessed if it can be implemented as AaaS internally). In this regard, an initial assessment of the technological readiness (i.e., data sourcing, access, integration, and delivery), the available or potential analytical expertise and analytical capabilities (i.e., analytical readiness) is conducted. If the project idea is assessed as strategically relevant and feasible, then, an internal implementation is pursued as far as possible. Non-strategic topics, however, are outsourced due to their minor business relevance. This principle highlights the critical importance of how well the business department understands the business value they want to achieve (i.e., business acumen and understanding).

"We particularly select the cases with a high strategic impact and a high complexity in regard to the analytical method necessary. In doing so, we encourage and challenge our employees to make sure we develop the best people" Head of Artificial Intelligence & Machine Learning, VehicleCo, 2017

DP4. When pursuing AaaS, an organization has to develop corresponding knowledge and capabilities. This includes: (1) data sourcing, access, integration, and delivery as well as connected data sources and continuous data streams (i.e., technological readiness), (2) analytical expertise and analytical capabilities (i.e., analytical readiness), and (3) domain knowledge to understand what is hidden behind the company's data (i.e., business understanding and acumen). Portfolio management must assess these capabilities since they determine implementation costs and the evolution paths of business analytics services. For instance, as *CarCo*, *VehicleCo*, and *PremCo* matured with respect to these three dimensions, three archetypical paths became evident in the empirical data. These pathways characterize how an analytics service can be further developed depending on an organization's maturity on technological readiness, analytical readiness, business acumen and understanding (due to page limitations these pathways are not illustrated in detail). For instance, to acknowledge these pathways the portfolio management tool references to and documents the underlying technological infrastructure (e.g., data source systems and streams) to consider the technological readiness. Further, the responsible data scientists and developers are documented to ensure the consideration of the analytical readiness. Finally, the business uses cases, their responsible employee, as well as a product owner from the analytics unit to consider aspects of business understanding form part of the portfolio management tool's data fields.

5 Conclusion

Although business analytics receives considerable attention in practitioner and academic literature, little research is providing empirical evidence on value realization and utilization so far [16]. Building upon the holistic enterprise perspective of the socio-technical systems theory, we report on the results of a 3-year ADR project, in the course of which we designed and implemented a database that supports the management of an AaaS portfolio. In this article, we illustrate our problem design and solution and present the accumulated knowledge, which results from the formalization of learnings. There are three key limitations in the light of which our research results have to be interpreted. First, our research was conducted in form of a collaborative research initiative. Since ADR projects may suffer from a bias related to the subjectivity of the involved researchers, we included researchers from outside of the project in our team and involved multiple researchers in the coding of our qualitative data. Second, since this

ADR project was exclusively conducted at a single company, our results may suffer from limited generalizability. To ensure that our proposed solution applies to a class of problems (and not only to the specific problem instance at CarCo), we involved external experts in multiple phases of the research project (e.g., focus group workshop with 9 analytics experts and three additional interviews with *VehicleCo* and *PremCo*). Third, guided by the extant body of knowledge as well as the project-based approach of *CarCo* to the management of AaaS our results bear similarities to the existing body of knowledge (e.g., requirement of a detailed service description). With our meta-requirements and design principles for the design of a service portfolio management tool for AaaS, we contribute a nascent design theory [43] to the emerging literature on AaaS [44, 45]. In particular, we address a lack of research on instruments and practices for the management of business analytics to realize the business value [11, 13]. Given the important role of portfolio management for the development of successful service offerings [9, 10], we develop a prescriptive instrument for the management of AaaS portfolios informed by STS theory. Ignoring the socio-technical complexity of implementing analytics services is a main reason for project failures [5, 6], our holistic approach covers all components of a socio-technical system. Particularly, the meta-requirements focus on the individual STS components (see Table 2). The design principles target the alignment and interrelationship of individual STS components (see Table 3). For example, conjunctively nominating demand-side business owners (DP2) leads to an alignment of governance instruments (i.e., the structure component) and involved actors. Similarly, assessing the technological readiness leads to an alignment of the actor's technology capabilities (i.e., the actor component) with the applied analytical instruments (i.e., the technology component). The results of our ADR projects reinforce the importance of coordinating the different socio-technical components in business analytics initiatives. Our contribution to practice lies in providing actionable guidance on how to implement a database that supports the management of an AaaS portfolio.

References

1. Davenport, T.: Big data @ work: dispelling the myths, uncovering the opportunities. Harvard Business Review Press (2014).
2. Davenport, T.H., Harris, J.G.: Competing on analytics: The new science of winning. Harvard Business Press (2007).
3. Dremel, C., Herterich, M., Wulf, J., Waizmann, J.-C., Brenner, W.: How AUDI AG Established Big Data Analytics in Its Digital Transformation. MIS Q. Exec. 16, 81–100 (2017).
4. Sharma, R., Mithas, S., Kankanhalli, A.: Transforming decision-making processes: a research agenda for understanding the impact of business analytics on organisations. Eur. J. Inf. Syst. 23, 433–441 (2014).
5. Demirkan, H., Dal, B.: The Data Economy: Why do so many analytics projects fail?, http://analytics-magazine.org/the-data-economy-why-do-so-many-analytics-projects-fail/.
6. Singh, P.: 10 Reasons Why Do Big Data And Analytics Projects Fail?, https://analyticsindiamag.com/10-reasons-big-data-analytics-projects-fail/.

7. Troilo, G., De Luca, L.M., Guenzi, P.: Linking Data-Rich Environments with Service Innovation in Incumbent Firms: A Conceptual Framework and Research Propositions. J. Prod. Innov. Manag. 34, 617–639 (2017).
8. Dremel, C., Herterich, M., Wulf, J., Brocke, J.V.: Actualizing Big Data Analytics Affordances: A Revelatory Case Study. Inf. Manage. (forthcoming).
9. Ajjan, H., Kumar, R.L., Subramaniam, C.: Information technology portfolio management implementation: a case study. J. Enterp. Inf. Manag. 29, 841–859 (2016).
10. Jeffery, M., Leliveld, I.: Best practices in IT portfolio management. MIT Sloan Manag. Rev. 45, 41 (2004).
11. Baesens, B., Bapna, R., Marsden, J.R., Vanthienen, J., Zhao, J.L.: Transformational Issues of Big Data and Analytics in Networked Business. MIS Q. 40, 807–818 (2016).
12. Chen, H., Chiang, R.H.L., Storey, V.C.: Business Intelligence and Analytics: From Big Data to Big Impact. MIS Q. 36, 1165–1188 (2012).
13. Tambe, P.: Big Data Investment, Skills, and Firm Value. Manag. Sci. 60, 1452–1469 (2014).
14. Galliers, R.D., Newell, S., Shanks, G., Topi, H.: Datification and its human, organizational and societal effects: The strategic opportunities and challenges of algorithmic decision-making. J. Strateg. Inf. Syst. 26, 185–190 (2017).
15. Abbasi, A., Sarker, S., Chiang, R.H.: Big Data Research in Information Systems: Toward an Inclusive Research Agenda. J. Assoc. Inf. Syst. 17, 3 (2016).
16. Günther, W.A., Rezazade Mehrizi, M.H., Huysman, M., Feldberg, F.: Debating big data: A literature review on realizing value from big data. J. Strateg. Inf. Syst. 26, 191–209 (2017).
17. Bostrom, R.P., Heinen, J.S.: MIS Problems and Failures: A Socio-Technical Perspective. Part I: The Causes. MIS Q. 1, 17–32 (1977).
18. Leavitt, H.J.: Applied organizational change in industry: Structural, technological and humanistic approaches. In: Handbook of organizations. pp. 1144–1170. Rand McNally & Co., Chicago (1965).
19. Lyytinen, K., Newman, M.: Explaining information systems change: a punctuated socio-technical change model. Eur. J. Inf. Syst. 17, 589–613 (2008).
20. Holsapple, C., Lee-Post, A., Pakath, R.: A unified foundation for business analytics. Decis. Support Syst. 64, 130–141 (2014).
21. Boyd, D., Crawford, K.: Critical Questions for Big Data. Inf. Commun. Soc. 15, 662–679 (2012).
22. Lehrer, C., Wieneke, A., Vom Brocke, J., Jung, R., Seidel, S.: How Big Data Analytics Enables Service Innovation. J. Strateg. Inf. Syst. (2018).
23. Loebbecke, C., Picot, A.: Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda. J. Strateg. Inf. Syst. 24, 149–157 (2015).
24. Chatfield, A., Reddick, C., Al-Zubaidi, W.: Capability Challenges in Transforming Government through Open and Big Data: Tales of Two Cities. In: Proceedings of the 36th International Conference on Information Systems, Fort Worth, USA (2015).
25. Orlikowski, W.J.: Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations. Organ. Sci. 11, 404–428 (2000).
26. Markowitz, H.: Portfolio selection. J. Finance. 7, 77–91 (1952).
27. Cooper, R.G., Edgett, S.J., Kleinschmidt, E.J.: Portfolio management for new products. Perseus Pub, Cambridge, MA (2001).
28. Aas, T.H., Breunig, K.J., Hydle, K.M.: Exploring New Service Portfolio Management. Int. J. Innov. Manag. 21, 1 (2017).
29. Martinsuo, M.: Project portfolio management in practice and in context. Int. J. Proj. Manag. 31, 794–803 (2013).

30. Reyck, B.D., Grushka-Cockayne, Y., Lockett, M., Calderini, S.R., Moura, M., Sloper, A.: The impact of project portfolio management on information technology projects. Int. J. Proj. Manag. 23, 524–537 (2005).
31. Stettina, C.J., Hörz, J.: Agile portfolio management: An empirical perspective on the practice in use. Int. J. Proj. Manag. 33, 140–152 (2015).
32. Comerio, M., Batini, C., Castelli, M., Grega, S., Rossetti, M., Viscusi, G.: Service portfolio management: A repository-based framework. J. Syst. Softw. 104, 112–125 (2015).
33. Kohlborn, T., Fielt, E., Korthaus, A., Rosemann, M.: Towards a service portfolio management framework. In: Proceedings of the 20th Australasian Conference on Information Systems. pp. 861–870. Monash University (Online), Monash University, Melbourne, Victoria (2009).
34. Peppard, J.: Managing IT as a Portfolio of Services. Eur. Manag. J. 21, 467–483 (2003).
35. Iivari, J.: A paradigmatic analysis of information systems as a design science. Scand. J. Inf. Syst. 19, 5 (2007).
36. Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action Design Research. MIS Q. 35, 37–56 (2011).
37. Mathiassen, L.: Collaborative practice research. Inf. Technol. People. 15, 321–345 (2002).
38. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Q. 28, 75–105 (2004).
39. Webster, J., Watson, R.T.: Analyzing the past to prepare for the future: Writing a literature review. Manag. Inf. Syst. Q. 26, xiii–xxiii (2002).
40. LaValle, S., Lesser, E., Shockley, R., Hopkins, M.S., Kruschwitz, N.: Big data, analytics and the path from insights to value. MIT Sloan Manag. Rev. 52, 21 (2011).
41. Sonnenberg, C., vom Brocke, J.: Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research. In: Peffers, K., Rothenberger, M., and Kuechler, B. (eds.) Proceedings of the 7th Design Science Research in Information Systems, Las Vegas, USA (2012).
42. Venable, J., Pries-Heje, J., Baskerville, R.: A Comprehensive Framework for Evaluation in Design Science Research. In: Peffers, K., Rothenberger, M., and Kuechler, B. (eds.) Proceedings of the 7th Design Science Research in Information Systems, Las Vegas, USA (2012).
43. Markus, M.L., Majchrzak, A., Les Gasser: A Design Theory for Systems That Support Emergent Knowledge Processes. MIS Q. 26, 179–212 (2002).
44. Delen, D., Demirkan, H.: Data, information and analytics as services. Decis. Support Syst. 55, 359–363 (2013).
45. Naous, D., Schwarz, J., Legner, C.: Analytics As A Service: Cloud Computing and the Transformation of Business Analytics Business Models and Ecosystems. In: Proceedings of the 25th European Conference on Information Systems, Guimarães, Portugal (2017).