Activity-Based Costing as a Design Science Artifact

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Abstract

In this paper, we propose to consider the Activity-Based Costing (ABC) method as a design science artifact. We apply the three cycles of design science (i.e., relevance cycle, rigor cycle, and design cycle) to Activity-Based Costing. We argue that some cycles are addressed in literature to a certain extent, but that justificatory knowledge in the rigor cycle is missing. Applying such knowledge can provide valuable insights for systematically evaluating and improving an artifact. Therefore, we propose modularity and entropy as possible candidates for such justificatory knowledge. This paper contributes to ABC research by introducing a scientifically rigorous evaluation. This evaluation indicates several possibilities for design contributions to ABC. Moreover, the relevance of these new artifacts for cost accounting practice are discussed as well.

1. Introduction

The central mission of scholars in applied research domains should be to conduct research that advances academic knowledge while at the same time enlightens professional practice. Nevertheless, much published research is not contributing in intended ways to either science or practice [3,20,45]. The design science paradigm attempts to remedy this situation and fulfill this mission by providing a structure for research efforts and reports to ensure practical relevance, while adhering to the required academic rigor [21]. While the design science paradigm addressed the field of information systems research in particular, it is applied to other, more management-related fields as well [2,3,30,40]. This is not surprising, given the importance of the business/IT alignment issue. Despite earlier claims that IT should be designed following a given business context, contemporary arguments favor a design of business which takes into account the possibilities and advantages of IT [2,40]. This statement includes the need for a paradigm which considers a business or organizational design.

Despite the interest in organizational design, certain authors argue that a more specific methodology for management-related design science is needed [2], or remain critical of the possibility to apply the design science paradigm to management subjects [38]. This paper aims to contribute to this debate by discussing the application of the design science paradigm on a specific artifact, i.e., the Activity-Based Costing (ABC) method of the cost accounting domain. Rather than suggesting a generally applicable method for executing design science in management, or arguing the applicability of the design science paradigm to all artifacts of management domains, we aim to demonstrate the feasibility and usefulness of considering certain specific management methods as design science artifacts. By applying a generally accepted design science framework (i.e., the three cycles framework as published by Hevner [21]), we demonstrate how suggestions for further improvements for a particular management artifact can be made. This is achieved by explicitly considering the completeness of the relevance cycle, rigor cycle and design cycle. The relevance cycle of ABC seems well-established. While certain iterations of the design cycle can be observed as well, we will argue that the rigor cycle remains underspecified. We therefore propose to select a set of possible theories from the knowledge base of which parts can be used to evaluate the current state of the ABC method, and which can indicate opportunities for future research.

2. Research approach

Before we start analyzing ABC as a design science artifact, we should elaborate on two design science-related questions. First, can we consider ABC as a design science artifact? Second, which methodological framework can we use to analyze ABC as a design artifact?

The first question, can we consider ABC as a design science artifact? addresses the validity of our analysis. Originally, the goal of science was considered as to describe, explain and predict phenomena in the world. Understanding these phenomena through
scientific theories should suffice for practitioners to solve real-world problems. This idea is apparent in the distinction of Schön’s high ground of theory, which is contrasted with the swamp of practice [42]. This vision of science has been contested since the seminal work of Simon [44]. Since then, the rigorous improvement of man-made artifacts was considered as a science as well. Especially since the article of Hevner et al. [20], the acceptance of design science in the information systems (IS) research field is growing. However, interest in the design science paradigm is not restricted to the IS domain. Based on a similar perceived lack of relevance, a call for more design-oriented research has been heard from organizational research [40,45], management research [2,38], and the cost accounting domain itself [3,30]. Consequently, it should be feasible to consider artifacts from the accounting domain within the design science paradigm.

More specifically, ABC could be considered as being a method artifact which has been developed [34]. ABC prescribes the steps which should be taken to develop an instantiation of a cost accounting system. The development of the method itself has been discussed in depth by Jones and Dugdale [24]. The ABC method has been published in several papers [33], and is discussed in numerous textbooks for cost accounting [14]. In the method, it is clearly stated that instantiating an ABC system is a design activity as well (e.g., “Designing ABC systems” [14:342] or [12:98]). The fact that various scientific publications describe such ABC instantiations [15,36,39] means that the design of the instantiations is considered to be relevant to the research community as well. Consequently, a sufficiently detailed description of the artifact is available. Moreover, leading design science authors have described ABC as a design science artifact as well [22], claiming that the original development of ABC happened similarly to design science, albeit named differently (i.e., Action Innovation Research [28]). It could also be argued that various design iterations have already been performed for ABC. For example, it has been reported that data gathering for ABC systems is difficult [26]. At the instance level, this could be resolved by using new technologies. For example, Gnoni and Rollo have shown that data collected based on RFID technology can provide the kind of data needed for ABC [17]. At the method level, an adapted ABC approach, called Time-Driven ABC, has been proposed [26].

In order to assess ABC as a design science artifact, we will use the three cycle framework of design science as proposed by Hevner [21]. This framework provides the answer to our second question, i.e., which methodological framework can we use to analyze ABC as a design artifact? The three cycle framework represents design science as “an embodiment of three closely related cycles of activities” [21:87].

First, the relevant opportunities or issues which will be addressed in the research need to be identified in the relevance cycle. Design science emerged as a reaction to the perceived lack of relevance in traditional IS research, which explains the importance of this cycle. The relevance cycle also prescribes that, once a new artifact is designed, it should be introduced in the application domain for study and evaluation. The results of such an evaluation determine whether additional iterations are required. In literature, many support can be found for the relevance of ABC as a design science artifact, as being a part of the cost accounting stream. Cost accounting was originally brought into life to solve the managers’ need for accurate cost information to decide upon product introduction, discontinuation, price (and volume) setting, etcetera. The information provided by traditional financial reporting appeared to be insufficient for this goal, as it served other purposes [24]. Both different types of data (i.e., at the instance level) as well as a different way for performing cost allocation (i.e., at the method level) were required. A major concern within the cost accounting field, was the correct attribution of indirect costs. Whereas these costs were traditionally simply allocated based on the number of direct labor hours, modern production environment proved to be more complex, requiring more advanced allocation techniques. ABC was proposed as a more advanced and multi-staged method to better calculate and attribute costs in such environments where overhead costs are more important than direct (labor) costs. The method has been applied in its intended application domain for field testing, with reports available in the production and manufacturing [36], library [15] and IT [39] domain. Consequently, ABC can be considered as a method artifact based on a problem statement from the cost accounting context, which has been introduced in this environment to undergo field testing as well. Therefore, we state that valid relevance cycles have been performed for ABC.

However, the rigor cycle and design cycle are documented less explicitly. Therefore, we will explore these cycles more thoroughly in the following sections.

3. Rigor Cycle

Hevner describes the rigor cycle as follows [4, p. 87]: “The rigor cycle provides grounding theories and methods along with domain experience and expertise from the foundations knowledge base into the research.” The development of ABC has been driven mainly by needs from the organizational environment.
Nevertheless, some confrontations with theoretical foundations from the knowledge base have been documented as well. For example, based on the comments of Eli Goldratt and his Theory of Constraints, various adaptations have been made [28:107]. Moreover, the need for a more theoretical basis has been hinted at by focusing on “scientific” ABC [24,27,31]. In scientific ABC, statistical techniques such as multivariate regression analysis and linear programming are applied [28]. However, this does not satisfy the need for using the knowledge base, since it does not guide the development of the artifact [19]. In this paper, we suggest to use modularity and entropy for this goal. We will use the term justificatory knowledge to describe this use of the knowledge base [18]. Since (a) modularity cannot be considered to be a complete theory, and (b) we only adopt a limited part of natural science thermodynamics (i.e., the entropy concept and definition), we do not claim the use of a kernel theory [18]. Nevertheless, the modularity and entropy concepts provide us with a sound basis to motivate the merits of the ABC method, and identify opportunities for possible improvements.

3.1 Modularity

A first theoretical validation of ABC is to see whether it better suits the modular structure of an organization than other cost accounting approaches. Organizational modularity recently received much attention in both research and practice. Campagnolo and Camuffo provide a literature overview of 125 management studies which use the modularity concept [9]. They define modularity as “an attribute of a complex system that advocates designing structures based on minimizing interdependence between modules and maximizing interdependence within them” [9:259]. It has been argued that modularity needs to be considered as a relative attribute of complex systems (such as organizations), meaning that within a single artifact, different levels of modularity can exist [43]. The mirroring hypothesis [8,10] even states that a certain modular structure (e.g., on the product level) will influence organizational processes and departments [16,43].

Consequently, cost accounting systems could be considered as a modular structure as well. Accounting systems provide information on the actual products made by the organization. Therefore, they need at least to take into account the modular structure of products, processes and organization. Indeed, it has already been argued that a cost accounting method with a more modular structure such as ABC is required to adequately analyze the costs of modular products [46]. While not all products are inherently modular, an increasing importance on this characteristic can be observed, considering the tendency towards customer-driven production, and a high number of product varieties.

If we are to analyze the modular structure of a cost accounting system in the build and evaluate phases of a design science project, we should elaborate on the interpretation of the modular structure of ABC. The main contribution of ABC is that it allows a better attribution of indirect costs. While the impact of decisions regarding products on direct costs is straightforward, the impact on indirect costs is less clear. However, when these indirect costs are regarded as fixed costs, they are not at all considered in the decision-making process. Therefore, the indirect costs need to be assigned to so-called cost objects. Cost objects can be anything for which a cost measurement is needed (e.g., products, parts, customers, locations). Therefore, the cost objects provide a starting point for the modular structure which needs to be described by the cost structure. For example, when the products are considered as cost objects, the product portfolio can be regarded as the modular structure. Following the mirroring hypothesis, a similar modular structure is required for the cost structure. According to modularity, a modular structure is designed based on the separation of concerns principle: each concern should be separated in a designated module. Therefore, we should clarify which types of concerns are separated in different cost accounting approaches. Consider now three different methods to allocate indirect costs.

First, blanket overhead rates could be used [14:50]. In this approach, all indirect costs are allocated to cost objects based on a single overhead rate (e.g., direct labor hours or number of units produced). Consequently, no modular structure is identified in the indirect costs, and no concerns can be identified.

Second, a two-stage allocation process based on cost centers could be used [14:51]. In a two-staged process, overhead costs are allocated to production cost centers [14:55]. Production cost centers are departments which contribute directly to the production of products or services. Certain overhead costs can be attributed directly to production cost centers (e.g., equipment repair costs), while other costs are related to service cost centers and need to be allocated to production cost centers subsequently. Service cost centers are departments of the organization which support other departments, but are not related directly to the production of products or services. Therefore, the concern which drives the modular structure of the cost allocation to cost objects is the departmental structure of the organization.
Third, a two-stage allocation process based on activities could be used. This approach is similar to the two-staged allocation process based on cost centers. Activities allow a more fine-grained structure than cost centers, because multiple activities can be identified in each production cost center. Moreover, the use of activity drivers enables a more realistic allocation of service cost centers. Because the costs related to service cost centers are allocated to production cost centers in a traditional two-staged approach, a single cost driver is used. In ABC, a separate activity driver can be used for every activity. For example, this allows to allocate costs of a procurement activity to products which require many different orders, even when the product is created in low volumes. Using a traditional cost centers allocation approach, this cost would be allocated based on product volumes, which results in an underestimated cost of low-volume products (triggering many procurement activities). The concern which drives the modular structure is therefore the activities which are performed.

### 3.2 Entropy

As discussed, ABC should reduce the complexity and uncertainty of managerial decision-making by providing more specific and accurate information. In engineering sciences, entropy is a widely employed concept to study the complexity of modular systems, being a measure of how much knowledge we have (or do not have) of a system. Hence, as we claimed in the previous subsection that we can consider (activity-based) cost accounting systems as modular structures, and both entropy and ABC aim to study (and reduce) the complexity of systems in one way or the other, it seems an interesting avenue to use the entropy concept as another (more specific) theoretical validation base for the ABC artifact.

While many definitions of the entropy concept exist, the approach as taken in statistical thermodynamics is one of most commonly referred to. In statistical thermodynamics, entropy is defined as the number of possible microstates consistent to the same macrostate of that system [4]. Here, the macrostate refers to the whole of externally observable and measurable (macroscopic) properties of a system (typically temperature or pressure of a gas), whereas the microstate depicts the whole of microscopic properties of the constituent parts of the system (i.e., modules and particles). The higher the number of microstates consistent with one macrostate, the higher the entropy, and the higher the uncertainty we have regarding the system. Indeed, when we observe a macrostate which can only be associated with one microstate, our knowledge of the system is complete (i.e., there is only one configuration of the constituent parts of a system which can result in the observed external properties of the system). Conversely, when several microstates are consistent with the observed macrostate, our knowledge of the system decreases (i.e., we do not have full knowledge of how the internals of the system resulted in the observed outcome). Hence, for certain applications it makes sense to put effort in finding ways on how to control entropy of artifacts, generally by adding structure to the system (i.e., including partitions in the system to avoid uncontrolled coupling and interactions between the particles of the system and exporting knowledge regarding these partitions to observable variables).

While the entropy concept clearly originated in traditional engineering sciences, applications of this concept to many other scientific fields, including management and business-oriented research, can be noted (e.g., software development processes [47], organizational decision making [23] or corporate diversification [37]). Some researchers also applied to the concept for analyzing financial and accounting related reporting (see e.g., [1,29,41]) and business process analysis [25]. However, few approaches can be found to apply the statistical thermodynamics concept of entropy to business or accounting related domains.

In [5], we already made an initial attempt to apply the statistical thermodynamics concept of entropy to business process analysis in a cost accounting context. In doing so, we considered each business process type $BP_i$ (e.g., production of a car) to consist of several task types $t_k$ (e.g., assembly of the doors, assembly of the wheels, etcetera). Once they are executed, each of the process types has a number of specific instantiations $j$: $BP_{ij}$ (e.g., a car with chassis number 200495) as well as instantiations $m$ for the tasks the process consists of: $t_{k,m}$ (e.g., assembly of the doors to car number 200495). A resulting instantiation space is depicted in Figure 1. Aiming to employ the thermodynamics analogy, the individual task instantiations can be seen as the “particles” in the business process system. Whereas in typical thermodynamics, properties as speed and position of the particles are studied, its counterpart in the context of tasks would be typical properties like the throughput time of an individual task instantiation in a process, its correct or erroneous outcome, the costs and resource consumption of an individual task, etc. Hence, the microstate is given by the union of the values of properties (e.g., costs) for each individual part (i.e., task instantiation). The corresponding macrostate is the (aggregated) information available for the observer, such as the total throughput or cycle time, quality or output measures, total costs, resource consumption, etcetera in a typical business process setting.
Next, several information aggregation dimensions, occurring in practice, were identified \cite{5} and are indicated by the groupings in Figure 1. The essence of each of these aggregation dimensions is briefly described in Table 1. One can easily observe that each of the considered aggregation dimensions results in a different amount of entropy (and hence, loss of information). Typically, aggregation dimension 1 provides the most fine-grained (cost) information possible, and therefore exhibits the lowest degree of entropy. In contrast, aggregation dimension 6 exhibits the highest amount of entropy as it aggregates information on several dimensions at once. Suppose that task $t_{1,1}$ in Figure 1 exhibits a disproportional high cost. One can easily see that aggregation dimension 1, in which individual information of this task is stored for each instantiation, easily allows for problem detection (i.e., being aware that something has gone wrong) and traceability (i.e., being aware were the cause of the problematic observation is situated). However, when one considers information aggregations of dimensions 2 till 6, it is clear that both the unambiguous detection and traceability of the outsize cost of the particular task becomes more problematic.

Consequently, we can now notice, first, that a more fine-grained (modular) cost structure registration again seems to be associated with more information about the considered (cost) system and hence, a lower degree of entropy. Second, based on this business process instantiation space specification and aggregation dimensions, it should be possible to consider the modular structure present in a specific cost accounting system (cf. Section 4.1), analyze the aggregation dimension they are situated at, and evaluate them according to the entropy concept.

\textbf{Figure 1:} The considered business process instantiation space \cite{5}. 

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**Table 1: Short description of the six considered aggregation dimensions [5].**

<table>
<thead>
<tr>
<th>Aggregation dimension</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Information is gathered and recorded at its most fine-grained level: for each individual instantiation of each business process type, the costs per task instantiation on an individual information object are recorded.</td>
</tr>
<tr>
<td>2</td>
<td>Information regarding two or more “information units” $k$ is aggregated within the scope of one single business process instance $j$.</td>
</tr>
<tr>
<td>3</td>
<td>Cost information is aggregated over all tasks $k$ per business process instantiation $j$. A more general case of aggregation dimension 2.</td>
</tr>
<tr>
<td>4</td>
<td>Cost information among all instances $m$ of a particular task $k$ within business process $BP$, is aggregated.</td>
</tr>
<tr>
<td>5</td>
<td>Cost information is aggregated according to a certain time $t$ which has elapsed.</td>
</tr>
<tr>
<td>6</td>
<td>The cost information regarding all (task) instances of the considered business process type becomes aggregated.</td>
</tr>
</tbody>
</table>

4. Design Cycle

The design and evaluate cycle in design science is described as follows [21:87]: “The central Design Cycle supports a tighter loop of research activity for the construction and evaluation of design artifacts and processes.” In this cycle, the design decisions of the artifact are elaborated upon, and the artifact is evaluated. The outcome of the evaluation is used as input for subsequent design cycles. Several reports of research which can be considered to be such design cycles for ABC are available. These can be positioned at the level of the method itself, or on the level of the instantiations. At the instantiation level, such research has, for example, focused on the cost of gathering information for an ABC system. For example, a trade-off exists between the benefits of the insight and the cost of gathering data [27]. Kaplan acknowledged that the cost of gathering data was substantial for many ABC instantiations [26]. However, Gnoni and Rollo have shown that using new techniques, such as RFID, this gathering cost can be reduced substantially [17].

Such research shows that the way of implementing an ABC system can be improved, without changing the method itself.

Moreover, several design cycles have been performed on the ABC method itself. As discussed above, the initial development of the ABC method can be considered as design science [22,28]. Additionally, changes to the method have been described in [24:140]. These changes had such an impact that a distinction between different “waves” of the ABC method was made. For example, in the second wave, the original authors dissociated themselves from the idea that all costs needed to be allocated to products. Instead, cost should be interpreted on the level of activities which consumes resources (e.g., batch costs should be regarded at the level of batches, and should not be allocated further to products). This indicates changes to the method itself, instead of merely to the way it needs to be implemented. Moreover, some of these changes are motivated by an evaluation of the ABC method against criteria from, e.g., the Theory of Constraints [24].

Notwithstanding these examples of already performed design cycles, it could be argued that these results have not been executed under a design science methodology. Consequently, it cannot be expected that these research projects adhere to the evaluation criteria which are common in the design science community. It is required that certain evaluation criteria are defined, in order to evaluate which aspects of the artifacts are improved by the newly proposed design. For ABC, such evaluation criteria can be retrieved from literature. For example, Drury [14:336] argues that cost accounting system are needed for decision-making because (1) certain indirect costs are relevant for decision-making; (2) information systems need to direct the attention to potentially unprofitable products; and (3) product decisions are not independent, and different aggregation levels need to be considered: a cost accounting system therefore needs to be able to provide information at a detailed level, as well as at an aggregated level.

These criteria can be evaluated in different ways. For example, several empirical research methods can be used, such as qualitative (e.g., case studies) or quantitative methods (e.g., confirmatory focus groups). However, Hevner et al. include a broader scope of accepted evaluation methods, including analytical evaluation [20]. In an analytical evaluation, the “structure of the artifact is analyzed for [static or dynamic] qualities” [20:86]. We will perform such an analytical evaluation for the ABC artifact. More specifically, in the subsequent sections, we will use the modularity concept to perform an initial analysis regarding the first and third criterion, while the entropy
concept may offer insights regarding (primarily) the second and third criterion.

### 4.1 Modularity

The evaluation of ABC using modularity provides arguments for the first and third evaluation criterion.

The first evaluation criterion states that certain indirect costs are relevant for decision-making, whereas in traditional cost accounting systems, such costs could be assumed to be fixed. Such fixed costs do not impact management decisions, since they cannot be avoided by, for example, excluding a certain product from the product portfolio. Consequently, it should be argued that ABC provides a better method to allocate these costs to products than other cost accounting methods. As discussed in Section 4.1, the modular structure of activities is more fine-grained in comparison to cost centers. This allows the cost accounting system to have a structure which is similar to the actual production processes of the organization, instead of its organizational structure. Current management approaches focus more on a horizontal, business-process oriented approach, as contrasted to a more silo-oriented approach, which focuses on organizational departments. This has led to the call to consider business processes as first-class citizens [25,35]. The exact match between business processes and cost accounting systems should be explored further in future research. Nevertheless, the similarities between the need to identify different aggregation levels in modular business process designs [35] and different aggregation levels in ABC (e.g., unit level, batch level, product level and factory level) indicate promising results. The more fine-grained modular structure of ABC accounting structures allows a more precise allocation of indirect costs.

The third evaluation criterion states that product decisions are not independent. Even with a more fine-grained allocation, which was discussed above, such dependencies are not necessarily clear. For example, many organizations produce several product variants in order to respond to varying customer preferences. In order to properly trace the cost of all product variants, different activities for every product variant need to be created [13]. When these products variants are regarded as low-volume cost objects, it could be that their estimated cost will increase, as is often the result of an ABC allocation. However, it is likely that these product variants use many common components. By recognizing these components (which requires a fine-grained modular cost structure), the impact of the cost of shared components can be made visible. Therefore, low-volume products will not systematically become estimated as more expensive. It has been argued that ABC accounting approaches will encourage companies to choose for more modular products as they use parts (i.e., “standardized” components) which are used in other (high-volume) products as well, cost less and hence, will more unlikely be eliminated from the product portfolio [12:103]. Eventually, this may even lead to redesign products in order to use more common parts. The appropriateness of ABC for examining dependencies between product components has already been studied empirically in [46].

### 4.2 Entropy

In Section 4.2, we proposed to consider the amount of entropy in cost accounting systems, based on their employed aggregation dimensions. Such analysis assumes that the lowest degree of entropy (i.e., aggregation dimension 1) is preferable in this context. Indeed, cost accounting aims to provide accurate and detailed information for making management decisions (cf. Section 3). Therefore, one would expect that more fine-grained cost accounting systems imply lower entropy and more accurate and correct information for organizational decision-makers. As this reasoning based on entropy mainly focuses on the degree of traceability of deviating costs and their aggregations, this analysis primarily provides insights regarding the second and third evaluation criterion offered by Drury [14].

First, in a blanket overhead rates system, the aggregated overhead costs are allocated to cost objects based on a single overhead rate. This implies that all overhead costs are for instance divided among the product types $i$ proportional to the number of instantiations $j$ of each business process type $BP_i$ (each producing their own product type). In terms of our defined instantiation space and aggregation dimensions of Section 4.2, this means that aggregation dimension 6 is adopted as no further breakdown according to instances, tasks (information units) or elapsed time is taken into account. However, this claim only holds when the chosen (single) overhead rate adequately reflects the proportion of the costs incurred by the product types. Nevertheless, several indications are present in literature that such simplified assumption is often unrealistic. Indeed, different product types might have their own idiosyncrasies (e.g., being more or less complicated) and less frequently produced products might more costs per unit for a particular indirect cost due to a lower degree of economies of scale [11]. In such scenario, the costs of the high-volume products would systematically be overestimated, while those of the low-volume products become underestimated. This critique in fact led to the creation of the later developed
cost accounting methods in order to allocate the overhead costs in a more accurate way.

Second, in a two-stage allocation process based on cost centers, a more fine-grained cost structure is used, exhibiting a lower degree of entropy. However, as no unambiguous definition is provided into how the cost centers (or “departments”) are precisely determined, no clear evaluation based on the aggregation dimensions can be offered. Still, based on the assumption that a department will often only perform a set of activities to produce a certain good or service, one might assume that this cost structure tends to go towards a combination of aggregation dimensions 2 and 4, as not all indirect costs related to all individual tasks of which a business process consists, are necessarily summed.

Third, in an ABC allocation process, an even more fine-grained cost structure is employed, allocating costs to activities, before attributing them to a specific product. The provided information seems to be more appropriate as well, given the fact that multiple activity drivers are allowed. This description tends to evaluate this cost allocation process as situated at aggregation level 1. However, no clear criteria seem to be offered by the ABC method to determine which granularity should be used to define the scope of an activity. Even more, Drury [14:342] mentions that an essential and initial step in the ABC approach is the identification of activities, which “are composed of the aggregation of units of work or tasks”. Such expression leads to the conclusion that, at best, aggregation dimension 2 is employed as still several units of work or tasks (i.e., information units) are aggregated. Additionally, while ABC offers the possibility to allocate costs to batch-related activities (e.g., the configuration of manufacturing equipment), all overhead costs are still allocated to product or service units based on non-instance specific “drivers” (i.e., estimated proportions). Such allocation does not take into account the specificities of each instantiation of a task and product. Such differentiation may be important in a context with many custom-made products each requiring specific price and cost setting. But even for high-volume products, while price setting may indeed be based on the calculation of mean costs, instance traceability may still offer considerable advantages to engage in operational and cost-related business process optimizations (e.g., to allow for error and exception tracking). Consequently, ABC seems to be situated at a combination of aggregation levels 2 and 4, thereby exhibiting a lower degree of entropy compared to the two cost allocation systems discussed above. However, a more fine-grained structure is still needed to arrive at aggregation dimension 1.

Even reporting aggregated information, ABC systems appear to be very complex to roll out and keep up to date in a changing business environment [13,26]. Initial data collection for ABC systems is often time-consuming, and should be repeated whenever processes are adapted. If this data collection needs to be repeated with every business change, a lot of productive time is lost. This leads organizations to omit frequent updates to the ABC systems, causing inaccurate estimations [26]. As a response to these issues found in practice, new ABC iterations based on more coarse-grained aggregation dimensions were proposed, such as time-driven ABC [26]. The first step in this approach is estimating the cost per time unit of performing a certain activity. This information can be considered to be on aggregation dimension 5. While this results in easier measurements, it does not fulfill the need for fine-grained information (e.g., aggregation dimension 1), of which the usefulness was discussed in this paper. Consequently, based on the reasoning provided by our defined aggregation dimensions, one could argue to a certain extent that this new design cycle of the ABC artifact tends to go towards aggregation dimensions exhibiting a higher degree of entropy than their predecessors.

5. Discussion: towards a new Design Cycle

In the previous sections, we argued for the relevance of considering ABC as a design science artifact, discussed modularity and entropy as justificatory knowledge which may provide suitable starting points for studying ABC, and analyzed several design cycles which have been performed in the past. Our evaluation showed that, using both modularity as entropy, some shortcomings of the current ABC artifacts in literature could be identified which may offer opportunities for future new design cycle.

The optimization of the ABC artifact regarding these criteria should however not be deemed trivial. Therefore, it might be helpful to see how other disciplines succeeded into designing artifacts exhibiting (evolvable) modularity and low entropy. Such approach is for instance proposed by the Normalized Systems (NS) theory [32]. Here, the authors propose a limited set of formally proven theorems to arrive at deterministically fine-grained, evolvable and low-entropy modular structures for software architectures. However, its relevance and application to organizational artifacts such as business processes has been shown in the past (see e.g., [33]). For instance, the Separation of States and Separation of Concerns theorems imply that after the execution of each separate concern or information unit the system should store a unique, independent and traceable “state”, incorporating information about the execution of the considered concern or information unit. While
the theory proves the necessity of these theorems to obtain evolvable and low-entropy software architectures, its systematic application at the business process level strikingly aligns with the prescriptions obtained from our modularity- and entropy-based reasoning as discussed in Sections 4 and 5. This could for example drive a tendency to identify more fine-grained activities in the design of ABC systems, instead of defining them based on an “aggregation of units of work or tasks”. Next, NS theory explains that a really fine-grained modular structure is only practically feasible when operationalized through the systematic application of predefined patterns, called “elements” (i.e., a limited set of recurring and therefore optimized modular structures). Each of these elements incorporates one functional part (e.g., the implementation of a data structure, or processing activity), next to a set of cross-cutting concerns, such as persistency or remote access in a software architecture context. However, such deliberately designed organizational elements (e.g., “payment”, “message”, “sale”, etc.) might be useful at the organizational level as well [46]. Consequently, in NS reasoning, cost accounting would be considered as a cross-cutting concern, which needs to be integrated with every element. NS would argue that this is the only way to design (organizational) modules allowing for the combination of fine-grained modularity and a low degree of entropy. However, as can be seen from our previous discussion, this seems not the direction cost accounting is currently heading to.

Besides possible improvements at the method level, current evolutions also facilitate the actual realization of instances of the method (i.e., the actual design of real-life cost accounting systems complying with our suggested criteria based on modularity and entropy). Traditionally, ABC authors have argued that a trade-off should be made between a fine-grained registration and delineation of activities on the one hand, and overall cost-effectiveness on the other hand, as a more fine-grained activity structure implies higher registration and estimation costs of the drivers [27]. However, recent technologies allow for a more accurate, cost-effective and fine-grained (cost) information collection [17]. Therefore, research in new design cycles could investigate the effectiveness of such new technologies for ABC purposes. For instance, a further refinement of the ABC cost structure based on NS principles and its implementation in NS complying software might constitute an interesting approach.

6. Conclusion

In this paper we proposed to consider cost accounting approaches such as Activity- Based Costing as a design science artifact. As cost accounting systems have the purpose to provide managers with accurate and precise information on the costs of products and services for investment, pricing and other managerial decisions, it seems reasonable to expect that they are consistently designed, evaluated and improved in a scientifically sound way. However, little research is available which explicitly employs a theoretical framework to analyze and develop such approaches, while many critiques and shortcomings seem apparent in practice. Therefore, the relevance of considering ABC as a method in design science is clear. We suggested modularity and entropy as possible justificatory knowledge, which might serve as a use of the knowledge base to fulfill the rigor cycle. Moreover, an initial evaluation of existing cost accounting systems in terms of this justificatory knowledge was presented. On the one hand, this evaluation provided a well-founded rationale to motivate the relevance of analyzing ABC in cost accounting on its design characteristics. To our knowledge, such rationale was not yet present. On the other hand, the evaluation revealed several shortcomings, both on the level of the ABC method itself as on the level of its implementations. Therefore, suggestions for future research were made, based on the results of our evaluation. Consequently, this paper provides contributions for both accounting research and practice.

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8. References


