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Improving efficiency in budgeting – an interventionist approach to spreadsheet accuracy testing

Abstract

Over the past three decades, the reliance on sophisticated spreadsheets for budgeting has emerged as a standard in most organizations (Hesse and Hesse Scerno, 2009). Despite these technological advancements, rich empirical evidence documents that technologically induced 'spreadsheet errors' can substantially lower the accuracy of spreadsheets (Powell et al., 2009). These errors lead to suboptimal decision making and biased performance assessment.

The aim of this paper is to examine how spreadsheet error can be detected and prevented in the budgeting process. The research design applies models of spreadsheet accuracy testing (SAT) from Kruck (2006) and Vessey (1985). The paper, thereby, illustrates the error reduction process in budgeting as well as future spreadsheet error prevention through the use of VBA. The authors base the analyses on a unique dataset (interviews, participating observations, technical artifacts) gathered through 'action research' at a Chinese-Danish government organization, which uses budgets for assessing applications on research funding. Our results confirm and extend existing theory in the field of budgeting and SAT and provide interesting findings.

First, the paper shows that later spreadsheet error in budgeting is already rooted in a poor conceptualization of the budget template, in non-workflow-oriented imputation of data and poor documentation of data requirements. Second, it illustrates how the accuracy of spreadsheets substantially improves by introducing even simplistic VBA. Third, we present evidence that the flexibility of the budgeting template itself to changes in the organizational environment fosters spreadsheet accuracy in the long term.

Keywords: spreadsheet error, spreadsheet accuracy testing (SAT), budget, non-profit and governmental organization, public management, VBA.
JEL Classification: M10, M15, M40, M41, M48.

Introduction

Spreadsheets are widely used among organizations-to facilitate data processing (Hesse and Hesse Scerno, 2009; Teo and Lee-Partridge, 2001). While some spreadsheets are just used as an information register sheet, others contain sophisticated simulation models with the scale of comprehensive management information system (Panko, 1998). Especially the accounting function strongly relies on spreadsheets, e.g., for compliance or budgeting (Leon et al., 2010). Ensuring high quality in spreadsheets is especially crucial since inferior data quality induces costly, sub-optimal decision making (Galetta et al., 1996; Lueg, 2008, 2010). Also, external users might not be able to understand or to rely on data provided to them. Thus, current research shows an increasing awareness for preventing and detecting spreadsheet error (Leon et al., 2010; Powell et al., 2008). Despite the fact that budgeting is one of the most common and most important applications of spreadsheets, spreadsheet error in budgeting has received little attention. Hence, we pose the question: *How can spreadsheet error be prevented and detected in budgeting?* To investigate this question, we will analyze different types of spreadsheet errors and make suggestions based on different spreadsheet accuracy testing (SAT) that ensure spreadsheet error reduction for new or existing spreadsheets.

Following Jönsson & Lukka (2005), we take an interventionist approach ('action research') to conduct a revelatory case study in a Chinese-Danish governmental organization that uses budgets for granting funding to international research projects of universities. The organization's budget template for these research applications had been subject to critique by the controllers of the applying universities. Consequently, the CEO of the organization initiated a major change process, in which we were invited to participate as researchers.

Our main insights from the study are threefold: first, technical errors in the budgeting process are already induced during the conceptualization of the software. In our case, there was too much focus placed on the convenience of evaluating the budget-based application, and too little on the understandability and documentation available to applicants (Bromley, 1985). Second, our case illustrates that even simplistic VBA-applications can substantially reduce spreadsheet error in budgeting (Bromley, 1985). Third, we illustrate the importance of IT-system flexibility in budgeting to changes in the organizational environment (Nelson et al., 2005).

The remainder of this paper is organized as follows. Section 1 reviews the literature on SATs to elaborate on the focus of this study. Section 2 argues for our chosen methodology and case organization. Section 3 explains our results based on the three iterative phases of analysis, error detection, and the implementation of an improved template. The final section discusses and concludes the findings.

1. Literature review: spreadsheet accuracy testing and budgeting

Over the past 30 years, spreadsheets have become an integral part of business planning and reporting (Connors, 1983; Powell et al., 2008; Yoon, 1995). Among other applications, spreadsheets are extensively used for composing budgets (Kruck, 2006). The skills to compile a budget electronically are an established standard in the professions of accounting and finance, and expected even from undergraduate students (Davis, 1997). While high accuracy of information stemming from spreadsheets is crucial for decision making, empirical evidence both from the field and the laboratory indicates that spreadsheet error constitutes a major obstacle to informed decision making (Brown and Gould, 1987; Panko, 1998; Powell et al., 2007). A growing – but not yet extensive – stream of research addresses the issue of SAT. SAT suggests different models that can be used to plan, audit or correct spreadsheet error, thereby increasing spreadsheet accuracy and better decision making (Caulkins et al., 2005; Powell et al., 2007). It is the objective of this paper to perform a field audit of spreadsheet accuracy in budgeting based on existing SAT-models.

2. Methodology

Organizations are reluctant to report on insufficient spreadsheet accuracy (Kruck, 2006). We, therefore, opt to investigate the phenomenon of SAT – i.e., improvements organizations perform in their spreadsheet – by means of a case study from inside an organization. This case study is 'revelatory' as it intends to illustrate commendable approaches of dealing with spreadsheet error (Yin, 2009). Since many of the processes are cognitive and hidden from direct observation, we decided to become part of such an SAT-process. In order to do so, we take an interventionist perspective for our case study where we conduct active participant observations. Jönsson & Lukka (2005) recommend this approach in cases where the researchers need to gather qualitative data (like on cognitive processes such as SAT) but do not have complete control over the quasi-experimental setting. As a positive side effect, this kind of research both impacts organizations by making a deliberate attempt to improve practices in the field, and also offers new insights to researchers by providing practical evidence of theoretical significance (Ahrens and Chapman, 2006).

We were invited by the CEO of the case organization (we describe the organization in the next section). A major funding application template was about to undergo substantial improvements in terms of its spreadsheet accuracy. The CEO wished to cooperate with researchers on this issue, because researchers can be knowledge mediators of management innovations, similar to consultants (Lueg, 2009; Lueg and Schäffer, 2010). Our main contacts into the organization were the CEO and a 'case manager' who performed the role of a management accountant and processed the budget-based applications. One of the researchers followed the entire SAT-process over a time frame of 10 weeks as an active member. Our main sources of evidence are participating observations. We triangulated these observations through several informal interviews as well as through artifacts (e.g., computer programs, print-outs, forms and handbooks). During the SAT-process, we suggested two theoretical SAT-models that enabled the organization to improve their spreadsheet accuracy (Kruck, 2006; Vessey, 1985). We remained open to unforeseen events in the process, e.g., the decision to conduct VBA programming to implement the results of our prior SAT-model-based analyses.

3. Results: an integrated approach to SAT

3.1. The budgeting process at the case organization. For confidentiality reasons, we call the organization we chose for the revelatory case study on SAT 'Chinese-Danish Research Foundation' (CDRF). CDRF is not-for-profit and funded by eight Danish universities, the Danish Ministry of Science, Technology and Innovation, the Graduate University of the Chinese Academy of Sciences and the Chinese Academy of Sciences.

The main organizational objective of CDRF is to promote collaboration between China and Denmark on scientific research activities and international education. CDRF's major activities include the recruitment of international exchange students, initiation and participation in partnership agreement between Chinese and Danish research/educational institutions, and coordinating and advising ongoing research activities. The focus of our case study lies on a further activity that requires budgeting and involves parties external to CDRF: the funding of international researchers for stays abroad. For an application of a researcher, CDRF provides a budget template for the controllers of the participating universities. These budget sheets must contain the expected and actual research activities that incur expenses. They are filled out by the researcher, a university controller and a case manager at CDRF. The process can be described by the following six steps [process owner in square brackets]:

1. **Research proposal** [*researcher*]: Researchers contact a university controller concerning their planned, CDRF-fundable research activities abroad. They provide a cost estimate, e.g., information on the cost of travel or the length of the stay.
2. **Application for funding** [*university controller*]: The controller uses CDRF's budget sheet to register the information on the planned academic activities and submits it to a case manager at CDRF.
3. **Preliminary approval** [*CDRF*]: The case manager has to approve the preliminary budget and guarantees future funding on this basis.
4. **Actual expenditures** [*researcher*]: The researcher signals to the university controller when the research activities have been completed. The researcher reports the actual costs (based on receipts) in a revised budget to the university controller.
5. **Revised budget** [*university controller*]: The university controller checks the revised budget for plausibility and formal requirements and sends it to the CDRF case manager.
6. **Final approval and re-imbursement** [*CDRF*]: The CDRF reimburses expenditures to the university. Settlements between the researcher and the university are not part of CDRF's budgeting process. The process is visualized in Figure 1.

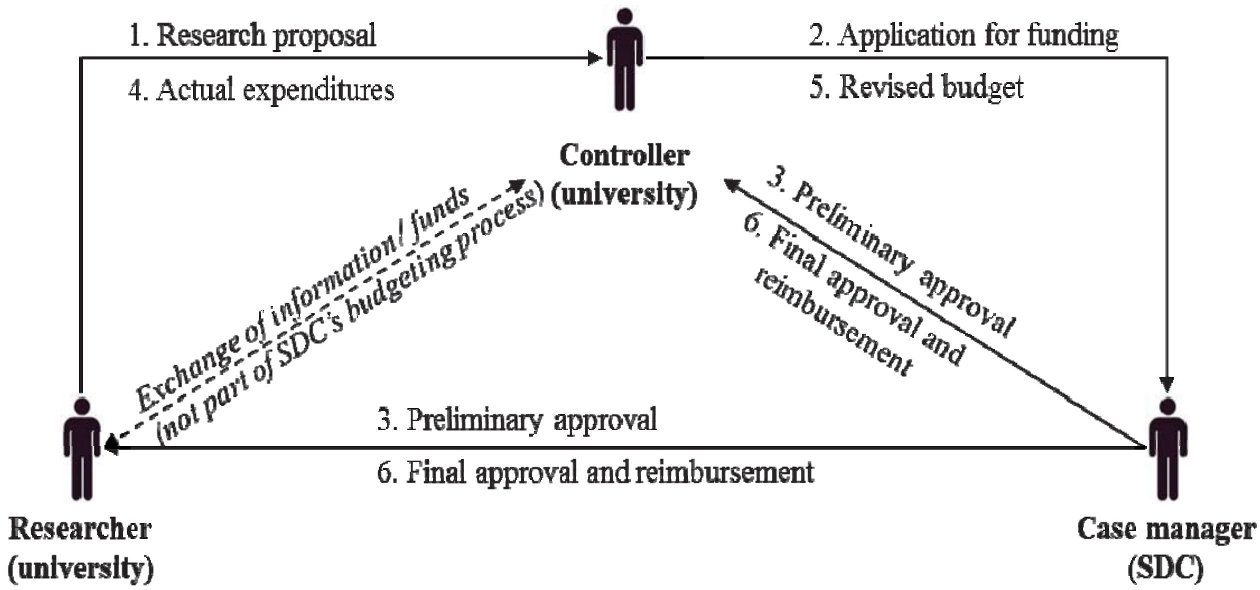

Fig. 1. Budgeting process at CDRF

Since spreadsheets are used in every step of the process, minimizing error is an important issue. At the start of our project, the CEO of CDRF pointed out three weaknesses. He first criticized the non-intuitive format of the budget template and reported that he received several complaints from university controllers who did not understand aspects of the budget template. Second, he expressed a desire for more accuracy of the budgets CDRF received from controllers. E.g., the template in its previous form offered imprecise categories and unit-intervals. For instance, it was not possible to express a research stay in days but only in fractions of months, which led to inaccurate reimbursements. Third, the CEO criticized that the complexity of the budget template prevented most of his employees to alter the existing template, e.g., according to new legal regulations. This slowed down approval processes if knowledgeable key employees had no free capacity. Our project hence attempted to increase understandability, accuracy and flexibility of the budget template for funding applications.

In the following three subsections, we explain how we took part in revising these errors and make suggestions for future projects. The 'team' to improve the budget template consisted of a case manager from CDRF and one of the researchers. We will now explain how spreadsheet error can be detected and prevented in the analysis phase (3.2), in the error detection phase (3.3) and in the implementation phase of the improved budgeting template (3.4).

3.2. Broad analysis of the template. For the fundamental analysis of the sheet – i.e. we looked at it as if we created it from scratch – we chose the SAT-model of Kruck (2006). Based on an extensive literature review on spreadsheet accuracy, Kruck (2006) proposes that accuracy improves substantially with the three factors of careful planning and design of the spreadsheet, low formula complexity, and extensive testing. Figure 2 illustrates the model.

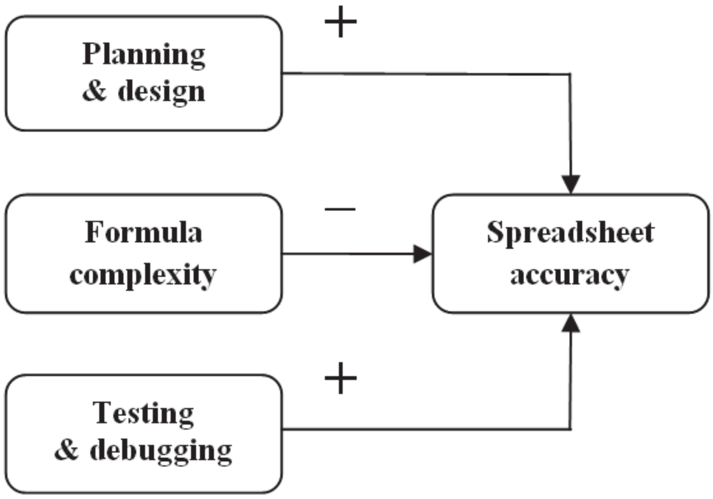

Fig. 2. SAT-model; adapted from Kruck (2006)

3.2.1. Planning and design. Kruck (2006) suggests that a spreadsheet should be arranged in a way that it fosters an intuitive but detailed understanding of the underlying (budgeting) process. This addresses the first criticism of the CEO on the budget template on a meso-level, i.e., its complexity and non-intuitive format. We made several improvements in this aspect. We started by analyzing CDRF's requirements for an application and the approval process. Thereby, we identified the process owners, the end products they have to deliver, and the process flow (see again Figure 1). We reorganized the order of worksheets in the budget template to follow this logic.

We also redesigned each worksheet in a way that university controllers could go through them step by step. This included re-arranging the data request away from the ex-post 'approval-perspective' of CDRF towards the ex-ante 'data-imputation-perspective' of the university controllers. As an example, we abandoned the arrangement of the budget template as a calendar. That format was too complex to understand for a user at once (Yoon, 1995), and also split the year into four quarters which did coincide with only few start and end-dates of the research projects. Thereby, the calendar format separated the 'estimate versus actual' information that researchers and university controllers needed for comparison. Instead, we re-arranged the template into a user-friendly 'estimate versus actual' format. Along the way of the reorganization, we identified algorithms that could be expressed in a simpler way (Bromley, 1985).

We also ensured that all cells in the worksheets had the relevant documentation for users to fill them out. Such documentation should include the descriptions of all values used in the spreadsheet and their sources, and should identify the parts of each spreadsheet that are used by other spreadsheets (Kruck, 2006). Based on interviews with case managers at CDRF, we identified the most critical cells and paid special attention to documenting these.

3.2.2. Formula complexity. The budget template should foster an intuitive and detailed understanding of the information requirements for the application (Kruck, 2006). This again addresses the first criticism of the CEO on the budget template on a micro-level. In the case of CDRF, we split up complex formulas, e.g., by summarizing positive sums and pertinent deductions in two cells (Bromley, 1985). Thereby, we simplified many complex formulas to simple two-cell subtractions. This also reduced cell dependency and made relations to predecessor cells more transparent. Also, we named ranges that were added or subtracted, e.g., instead of coding "SUM(A1:5+B1:2)", we gave names to ranges, ending up with additions like "SUM(AllowanceWorkDay+AllowanceWeekend)". This way, formulas became more self-explanatory for users of the budget template.

3.2.3. Testing and debugging. The factor 'testing and debugging' refers to the intensity the initial programmers tested the template to improve spreadsheet accuracy (Kruck, 2006). This process was quite extensive, and we report on it in more detail in the next subsection, using a SAT-model that goes into the specifics of debugging (Vessey, 1985).

3.3. Detailed detection of errors in cells. Panko & Sprague (1998) show in an experimental setting that explicit debugging activities increase spreadsheet accuracy substantially. Therefore, we systematically debugged the template using the classic model of Vessey (1985), which starts where the model of Kruck (2006) leaves off. We will go through the three steps of determining the problem, understanding the spreadsheet, and repairing errors.

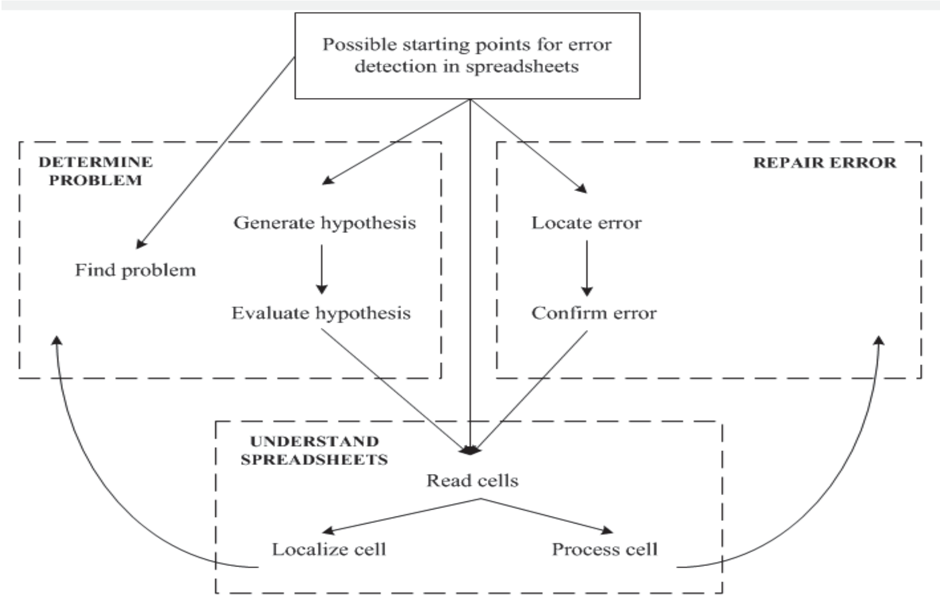

Fig. 3. SAT-model; adapted from Vessey (1985)

3.3.1. Determine problem. It is most efficient to identify the basic nature of spreadsheet error before checking individual cells. This way, the programmer follows the business logic and can identify errors along the calculations before actually reaching erroneous cells (Vessey, 1985). Interviews with the case managers confirmed that the most common mistakes in the budget template stem from entering incorrect data. These mistakes are detrimental to the efficiency of CDRF because errors are hard to detect: since research projects vary substantially with the field of research, there are few plausibility checks for funding applications. Thus, it is difficult to assess the accuracy from the template, unless the mistakes are quite significant or the case manager is very experienced. Errors are caused mainly because users are allowed to enter any number into the cells, but CDRF's old template provided few explanations, e.g., on the calculation procedure of subunits in the cells. This can be seen in the following example (Table 1).

Table 1. Calculation of research stays duration

2011		1st quater			2nd quater		
Name	Institution	Man month	Salary	Travel	Man month	Salary	Travel
Assistant Professors							
Name 1	Aalborg				1.00	56,239	10,000
Professors/totals							
Name 2	Aarhus	0.50	43,766	10,000			
Name 3	Copenhagen	0.25	21,883	10,000			

The core calculation is located in the columns "salary". Researchers get different allowances according to employment title (e.g., Assistant Professor or Professor) and their stay duration (here in China). Much of the needed information was located in other parts of the template, which was an obstacle for users to understand it. E.g., the allowance for the duration of the stay is paid on a daily basis but must be entered as decimals of a monthly salary. The template currently assumes that each month has 30 days, i.e., 0.5 month stand for 15 days. It was also valid to calculate 10 days as "=1/3" in the cell. The fact that the length of a month differs from 28 to 31 days created subtle differences that nevertheless constantly caused confusion and discussions with university controllers, as well as imbalance in the year end accounts of CDRF. As it can be seen from Table 1, there was no documentation how to address these or similar problems.

3.3.2. Understand spreadsheets. The second step is to explore the technical structure of the template. On a more conceptual level, we have already done this according to Kruck's (2006) model. The model of Vessey (1985) is yet more specific when understanding the template at the cell level. On a modular level, we familiarized ourselves with the references among cells. By doing that, we made several improvements, e.g., avoiding constants or entering an assumption sheet to have standardized currency exchange rates.

On a cell level, we checked every formula row by row and followed all references. While doing this, we assured compliance with CDRF's legal funding regulations. As an example, we present the module used for calculating the allowance of a Danish researcher in China (*Salary* = *Duration* × *Compensation* + 44% *Trip Bonus*). There are four categories of researchers (Senior Professors, Associate Professors, Assistant Professors & Postdocs, Ph.D. Students & Research Assistants). An important issue in CDRF's funding regulation is that persons in the last category do not receive a trip bonus. To make the template more user-friendly, we re-located the relevant bonus agio next to the pertaining cells in the template (see Table 2).

Table 2. Overview of calculation of trip bonuses

Funding to university			
		Annually*	Monthly
			Incl. bonus**
Senior Professors	729,430	60,786	87,532
Associate Professors	576,465	48,039	69,176
Assistant Professors	468,656	39,055	56,239
Ph.D. & Research Assistants	368,559	30,713	

Notes: *Standard salaries as of 2010. **Trip bonus.

3.3.3. Repair error. In step one and two, we followed the logic of the template according to the legal regulation, hypothesized on the critical areas, and checked all formulas including their references. We then started to repair errors from four main fields:

1. **Beneficiaries and cost centers:** Ph.D. Students have no eligibility for a trip bonus and therefore used to be listed and subtotaled in another category than the other researchers. We switched this and made Ph.D. Students one of the categories, locating them underneath the other researchers but with different formulas to calculate their allowance. We also added an overview of the calculation procedure displayed in Table 2.
2. **Intervals and units:** As described before, the duration of research stays could only be expressed as fractions of a month instead of in days. This caused heterogeneous provision of data by university controllers since months have different amounts of days. We intended to eliminate this source of error by switching to a day-per-year-based calculation, that is now more accurate and also add up to the 365 or 366 days of a year.
3. **Documentations:** To improve the documentation of the template, we used interview data from university controllers who were dissatisfied with the previous template. Within our research team, we also challenged each other in discussions to explain how cells needed to be filled out by university controllers. This further helped us to add substantial documentation, especially to the new features that the university controllers had not seen before.
4. **Focus on data requirements:** The previous version of the template was a tool for case managers at CDRF to calculate the funding. We realized that much of the data entered and calculations performed did not relate to the data requirements for the funding applications from university controllers. We systematically moved these CDRF-internal data requirements and calculation processes from the application template to other IT-based tools from CDRF that are for internal purposes only. This substantially simplified the template.

3.4. Implementation: ensuring high quality in the future using VBA-programming. The CEO attached high importance to improvements in flexibility, accuracy and understandability of the funding application template. We wanted to reduce the university controllers' opportunities to make mistakes and facilitate an easy use for them. Hence, we decided to implement the core features of our changes using Visual Basic for Applications (VBA). VBA is a background operation program that permits formula-free cells by programming user-defined functions, automatic processing of data and access to other programs and databases employing dynamic-link libraries (Walkenbach, 2010). Our prior analyses suggest that the crucial module to transform into VBA is the calculation of the researcher's allowance for the research stay, since most other expenses (travel etc.) can be reliably estimated well in advance. We added three VBA-buttons to the template. The button 'Calculate Allowance' adds a new research activity to existing or new members of the research team. 'Delete' allows removing the activity again, and 'Edit' alters their characteristics. With the above three buttons, the controller do not need to operate in formula-based cells at all anymore. The algorithms of these buttons are described in the Appendix.

Discussion and conclusion

The discussion concerns the models of Kruck (2006), Vessey (1985), and VBA-programming. The model of Kruck (2006) suggests that spreadsheet accuracy improves through planning and design, low formula complexity, and extensive testing. It is a more general, conceptual approach to assess spreadsheet accuracy and is easily visualized and intuitively understandable, while not being very specific at the same time. In the case of CDRF, it greatly helped in addressing one of the three criticisms of the CEO (understandability, flexibility and accuracy), namely the improvement of the understandability of the funding application template. As our first main insight from this study, we highlight that many of the technical errors in the budgeting process were already induced during the conceptualization of the budget template years ago. Yet – even at this highly conceptual level – the model might be too simplistic to mirror a debugging process in the field. Our case study has uncovered several interrelations between the three independent variables of the model. In particular, the case of CDRF suggests that the factors of planning and testing enrich each other in an iterative process. For instance, the necessity to implement and plan VBA-programming became apparent during the project. The planning process also interacted with the complexity of formulas, which were substantially reduced through the late decision to apply VBA. Last, we found evidence in the case that reducing the complexity of formulas requires re-testing the concerned modules in the template. Practitioners should be aware of both these interdependencies as well as of the iterative nature of the debugging process. Future research should test the model of Kruck (2006) with a larger scale dataset and then contribute to further theory building in the path-dependencies of the model.

The case study has shown how Vessey's (1985) model can be combined with the model of Kruck (2006) to increase spreadsheet accuracy. In the case of CDRF, it greatly helped in addressing two of the three criticisms of the CEO. First, it helped us to increase the accuracy of the budget template by checking all cells and their references without expanding the template. Furthermore, it helped us to increase the flexibility within the existing template; for instance, we switched from the monthly measurement of research stays to the daily version. Compared to the model of Kruck (2006), Vessey (1985) explicitly acknowledges the non-linearity and the iterative nature of the debugging process. On the critical side, this openness to non-linearity also implies that the success of the programmers will strongly depend on their knowledge of the subject that is modeled in the template (McKeever and McDaid, 2010). This makes SAT less systematic and might be – different from the case we investigated – less beneficial if less experienced programmers follow this model.

Last, VBA has proven to be an effective way of implementing the changes to increase spreadsheet accuracy as identified based on the two prior SAT-models. It helped in addressing two of the three criticisms of the CEO. First – as the second main insight from this case study – even the most simplistic VBA prevents error of users entering data and thereby substantially improved the accuracy of the template. Second, it made the template easier to understand by partitioning the previous 'calendar style' of the spreadsheets into small, simple modules. Thereby, we avoid to force users to understand the template's full complexity all at one, but direct their attention to the relevant data imputations only (Yoon, 1995). Overall, our SAT-project has received very positive feedback from the CEO. One of the critical aspects on VBA is that the accuracy problem is not fully eliminated but shifted from the user of the template to the programmer. Also, the flexibility *of* the template – as opposed to the aforementioned flexibility *within* the template – has decreased. Only one of the responsible case managers at CDRF is knowledgeable to alter the VBA-programming, which makes a lot of the processes depend on this person (on the knowledge problem, see also McKeever and McDaid, 2010). As the third and last main insight from the case study, we highlight that practitioners need to be aware of this and provide appropriate training to further employees as a backup option in case the main programmer is not available.

The limitations of this study provide avenues for future research. First, our interventionist approach to research might have influenced the case organization by facilitating the application of SAT-models they would not have employed themselves (Ahrens and Chapman, 2006). Future research may take a more distanced approach. In relation with that, our case study is revelatory – i.e., showing best practices in the field. Future research can conduct confirmatory studies, putting the identified dependencies of Kruck's (2006) model to the test. For this, larger scale evidence might be appropriate.

Despite the limitations, our study deserves some merit for addressing the issue of accuracy in the budgeting process from a theoretical perspective. The study furthermore receives some merit for responding to the call for more interventionist research that has a measurable impact on accounting practices in the field.

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Appendix A

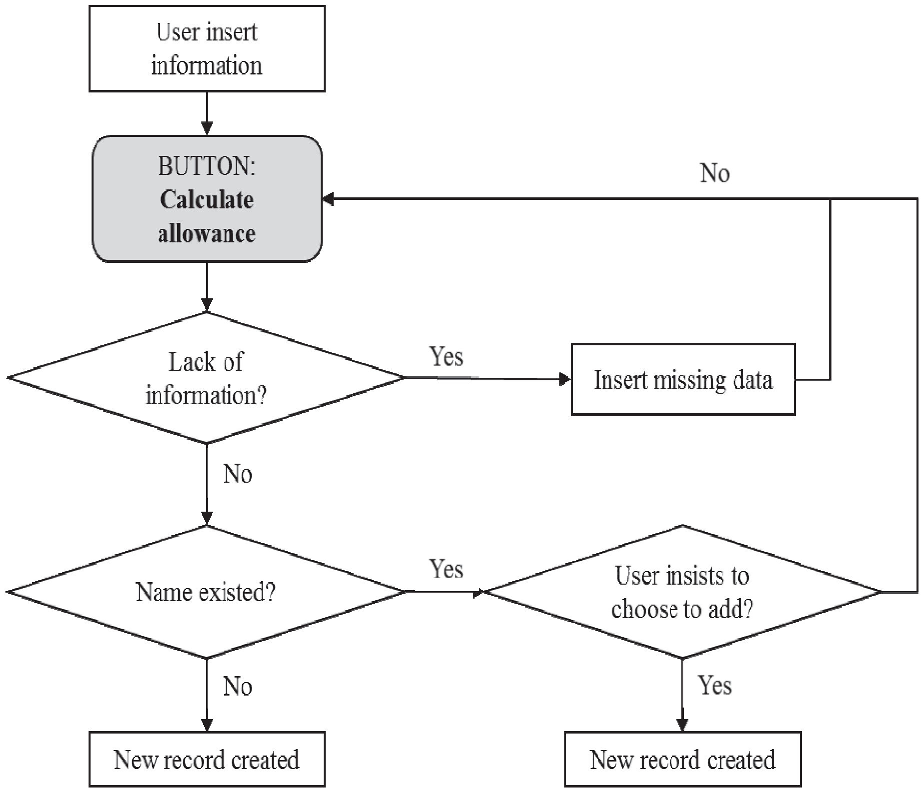

Fig. 1. VBA-button "Calculate Allowance"

Appendix B

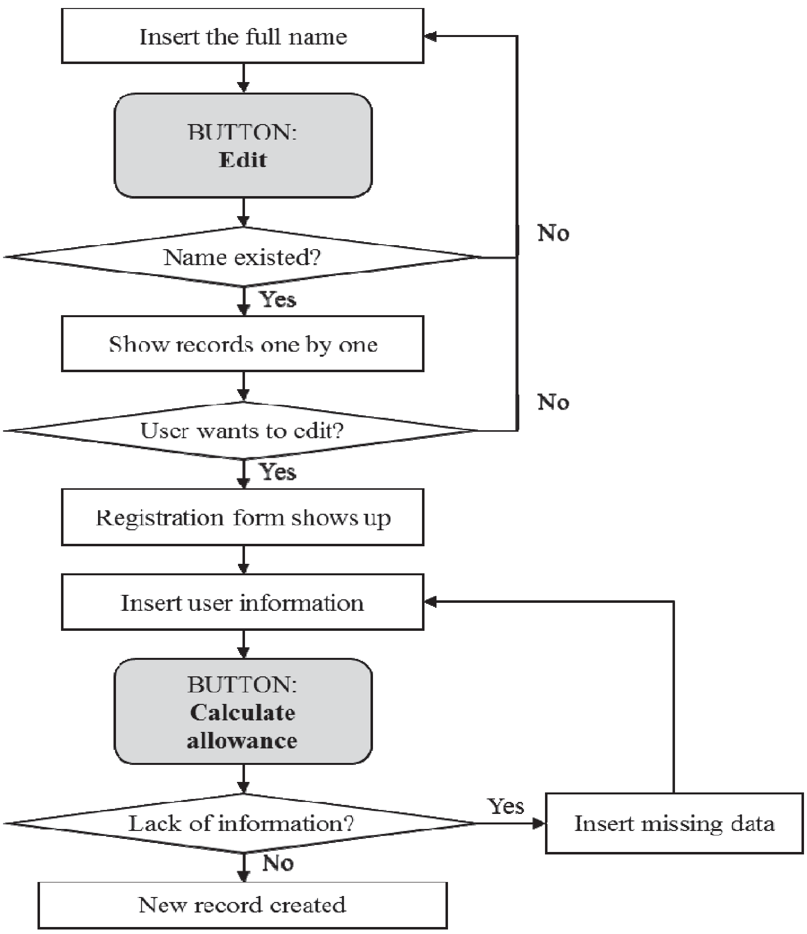

Fig. 2. VBA-button "Edit"

Appendix C

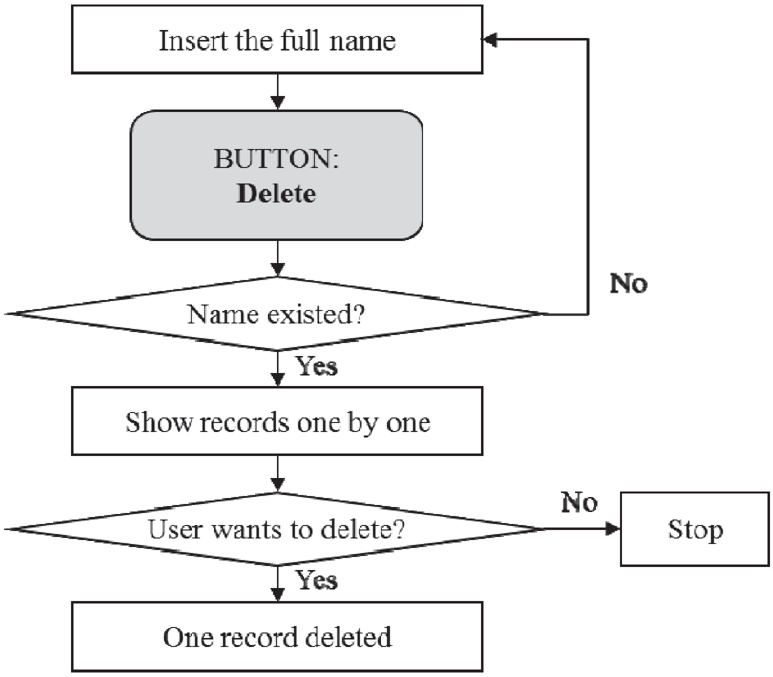

Fig. 3. VBA-button "Delete"