MASTER

Towards improved decision-making through the integration of financial information in BPMN models

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Towards Improved Decision-Making through the Integration of Financial Information in BPMN Models

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Abstract

Current business process modelling techniques lack the concepts to present accurate and clear financial information. Its availability would improve the design, planning, and control of business processes and, subsequently, improve management decision-making. Therefore, this study designed an approach which describes how financial information should be determined and included in BPMN models in order to improve the decision-making of managers. To that end, an integration of concepts from the Business Process Management and management accounting discipline was required. More specifically, the BPMN modelling language was extended with financial information from the RCA accounting method. The applicability of the approach in a real-case was validated by its successful implementation on the BPMN model of a real service product of a company. Through the implementation of the approach and the use of the resulting models, important financial information for decision-making becomes available in a manner that provides a better overview than existing techniques. Consequently, the resulting models offer great benefits to the decision-making of managers and the overall business of a company.
Management Summary
Current business process modelling techniques lack the concepts to present accurate and clear financial information. The availability of financial information in business process models would offer great benefits to the decision-making of managers and, subsequently, to the overall business of a company (Vom Brocke, Recker, & Mendling, 2010; Buhl, Röglinger, Stöckl, & Braunwarth, 2011). In addition, the management accounting discipline would benefit from the integration of financial information in business processes models. Several studies aimed to provide (some) financial information in BPMN models. Yet, none of the studies tested their conceptual financial extensions to BPMN in a real-case and none of them has a clear prescription for the actual implementation. Next to that, their concepts did not support all types of financial information (i.e. variable, fixed and overhead) and the factor of time. In order to address the problems described above, the main research question was defined as follows:

Main research question:
“How can the presentation of BPMN models be extended with financial information in order to improve management decision-making?”

Approach
The current study designed an approach which describes how financial information can be determined and presented in BPMN models with the aim to improve management decision-making. The BPMN modelling step is excluded from this approach. The applicability of the approach was validated through its successful implementation on a real-case. The approach consists of three steps and is presented below:

Step 1: Determine the financial information of individual activities and resources in a business process
Financial statements, information systems and other more intensive data gathering methods can be used to obtain the required financial information of the business process. The Resource Consumption Accounting (RCA) technique must be used to allocate overhead to individual activities and resources in the business process.

Step 2: Determine which (financial) information from the RCA model is important for the decision-making of the managers in the business process
The RCA model contains a lot of (financial) information which should not all be displayed, while it would make the BPMN model messy and unreadable. Therefore, it must be determined which (financial) information is important for the decision-making of the managers in the business process. For this purpose, four managers were surveyed and the results can be used as a starting point.

Step 3: Extend the presentation of the BPMN model with (financial) information
The BPMN modelling software must offer the possibility to present and update (financial) information in the BPMN model. For this study, the software program Microsoft Visio 2013 is used and linked with the (financial) information of an external data file.

Benefits from the application
Through the implementation of the approach and the use of the resulting models, several benefits are offered to the decision-making of managers:
- A clear, undistorted, and accurate overview of the causes of direct and indirect (i.e. overhead) financial information of each activity and resource in a business process
- The compatibility with fixed, variable and overhead types of financial information
- The concurrent use of multiple drivers to describe the consumption of resources
- The generation of knowledge which helps managers to identify inefficient processes or bottlenecks
- The generation of relevant information for both the long- and short-term in strategic business management
- The ability to run process simulations
- The compatibility of the approach with information systems

**Illustration of the result**

The result of the application of this approach on the illustrative case of a phone repair process (from Nauta, 2011) is presented in the Figure on the next page.

Currently, the activity elements present the total direct costs and the required time for execution. The status symbols are configured according to the difference between the cost in the RCA model and the expected costs of an activity. When the result is greater than zero, it is marked with a triangular orange exclamation point; and when the result is less than zero, it is marked with a circular green checkmark. The result for three different BPMN activity elements is shown below.

**Activity elements with (financial) information in the phone repair process**

The business functions (for instance: simple solver) present the utilization rate, the total cost, total hours spent on the process, and cost per hour. When the utilization rate of a resource is greater than 100%, a triangular orange exclamation point is shown. If the utilization rate of a resource is equal or less than 100%, a circular green checkmark is shown. The utilization rate of the simple solver is 106% and, as a result, its corresponding swim lane shows a triangular orange exclamation point.

Next to that, the dashboard at the bottom left of the business process shows that in the current situation the total cost and income are €9,507,17 and €22,890,00 respectively.

Finally, the probabilities of the alternatives in each process branch are shown. The probabilities are derived from the total amount of executions from the subsequent activities. For instance, the BPMN model shows that the probability for a simple repair and a complex repair is 96% and 4% respectively.

**Probabilities for the type of defect in the phone repair process**
The BPMN model of the Phone repair process extended with (financial) information
Preface
This master thesis is the result of my graduation project to obtain the degree of Master of Science in Operations, Management & Logistics. This research is done in cooperation with the company Ploos Energieverlening in Maarheeze.

First, I would like to thank both supervisors from the University of Technology Eindhoven, Remco Dijkman and Irene Vanderfeesten, for their great support and guidance through the whole research project. Initially, Irene started as my first supervisor on this research project and supervised the completion of both the literature review and the research proposal. Just before the actual start of the research project, she had to leave for maternity which, subsequently, led to the appointment of Remco as my first supervisor for the remainder of the research project. They have made every effort to make this change as smooth as possible for which I am very grateful. I will especially remember that they both forced me to come up with good, thoughtful and solid arguments, because if this was not (entirely) the case, they were able to expose it immediately and, subsequently, provide me with sharp and useful feedback. Without their supervision, the report would not have been of the current scientific quality.

Second, I would like to thank Frank Bakkers, Paul Vermeulen and Joost Ploos van Amstel of the company Ploos Energieverlening for their never-ending support and commitment to the project. Before I started, I heard from fellow students how difficult and time consuming it could be to obtain the required research data and feedback from a company. However, I never experienced anything alike at Ploos Energieverlening, because those supervisors made sure through the entire project that I obtained all necessary data and feedback, whenever needed. Next to that, I highly appreciated the fact that they treated me as one of their own employees and, more than once, talked about other more general subjects than the research project, from which I also learnt a lot. Of course, my gratitude also goes to all other employees which were part of this research project. The internship at Ploos Energieverlening was my first real business experience; an experience which I will never forget.

Finally, I would like to thank all other invaluable people in my life. I would like to thank my girlfriend for her support, interest and feedback throughout the project. Next to that, I would like to thank her, my friends and my brother for the fact that they made it possible that I could still relax and enjoy life during my graduation. Third, I am greatly indebted to my parents, for their unconditional support in every way in life.

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1. Introduction

Business Process Management (BPM) is a well-researched domain which has proven its benefits for everyday businesses (Vom Brocke, Recker, & Mendling, 2010; Bolsinger, Bewernik, & Buhl, 2011). Its success stems from its analytical and systematic view of business processes and from the different approaches it has produced during the years to manage and improve business processes (Nauta, 2011; Vom Brocke, Recker, & Mendling, 2010; Wynn, Low, & Nauta, 2013). In BPM several modelling languages are used to graphically articulate, discover and document the elements of an existing business process (i.e. business process model) in order to support managers in their everyday decision-making (Vom Brocke, Mendling, & Recker, 2008). In particular, BPMN is currently a widely used modelling language by companies and is still rising in its popularity (Vom Brocke, Recker, & Mendling, 2010). Nevertheless, current business process modelling techniques lack the concepts to present accurate and clear financial information. The availability of financial information in business process models would offer great benefits to the operational decision-making of managers and, subsequently, to the overall business operations of a company (Vom Brocke, Recker, & Mendling, 2010; Buhl, Röglinger, Stöckl, & Braunwarth, 2011). Since it would improve the design, planning, and control of business processes (Sonnenberg & Vom Brocke, 2014). For example, it could expose and reduce unnecessary costs in parts of a business process. In addition, the management accounting discipline would benefit from the potential integration of financial information in business processes models. While the management accounting discipline explores ways to capture the real-cost of operations accurately and to process this fine-grained cost information into a form suitable for planning, control, and decision-making (Thabet, Ghannouchi, & Ghézala, 2014; Wynn, Low, & Nauta, 2013; Wynn, Low, Ter Hofstede, & Nauta, 2014). In their effort, they aim to expose the business processes that lead to the financial entries in income statements and balance sheets which, subsequently, would lead to the monitoring and control of real accurate process data on which managers can actually act (Mueller-Wickop, Schultz, Gehrke, & Nüttgens, 2011). As a result from those potential benefits, several studies explored ways to clarify the financial information of business processes by making the use of methods and principles from both the accounting and BPM discipline. However, all studies have some significant limitations. The goal of this research is to solve those limitations and, subsequently, enable businesses to extend BPMN models with financial information and improve their decision-making.

The structure of this thesis is as follows. Firstly, the conceptual financial extensions to BPM modelling languages in earlier studies are presented in Chapter two. Secondly, Chapter three presents the scope, the problem identification, the research goal, the research questions and the research methodology. Thirdly, financial information is linked with BPMN elements in Chapter four. Fourthly, the determination of financial information of individual BPMN elements is described in Chapter five. Next, the determination of which particular financial information must be presented in a BPMN model to support the decision-making of managers is presented in Chapter six. Further, the approach description is presented in Chapter seven. Subsequently, the application of the approach in a real-case is presented and discussed in Chapter eight. Finally, the conclusion is presented in Chapter nine, including recommendations, limitations and directions for future research.
2. Background

This chapter discusses relevant insights from a previously undertaken literature study which researched the current integration state of financial information in business process models (Engelen, 2014). Earlier studies researched the integration of financial information in several business process modelling languages, namely Petri Nets, workflow nets, S-BPM, EPC, and BPMN. The results are categorized according to the researched modeling language and presented in the sections below. Finally, a conclusion is drawn and presented in Section 2.6.

2.1. Petri-Nets

The Petri Net model cost extension proposed by Thabet, Ghannouchi and Ghézala (2014), makes use of cost-annotated event logs (originally proposed by Nauta in 2011). An event log stems from the process mining discipline and records process information. The annotation of this event log is obtained by applying a cost model, which is constructed from cost drivers, cost functions, business process models and organizational models. As a result, this extension enriches the business process model with a wealth of information about the operational level (Thabet, Ghannouchi, & Ghézala, 2014, p.336). The approach of Thabet, Ghannouchi and Ghézala (2014) consists of three steps: (1) the extraction of cost information from cost annotated event logs, (2) the memory loading of the Petri Net model, and (3) the computation of cost information of the elements of the Petri Net. Their model includes a cost class described by a computation mode, type, amount (value) and currency. An average, maximum or minimum amount of the cost can be determined by this computation mode. The model supports the cost types (Section 4.1): fixed cost, labor cost, overhead cost and total cost. Subsequently, a Petri Net model extended with cost information is obtained. One major drawback of this extension is its lack of empirical testing.

Further, the Petri Net modelling notation is also used in the process accounting model (PAM) by Sonnenberg and Vom Brocke (2014). The PAM is expected to be capable of integrating and structuring accounting data and process data in support of the design of business processes. They adhere to the economic reciprocity principle, which “requires that event data capture changes in scarce means and reflect the ‘give-and-take’-pattern in order to be considered an event-accounting database” (Sonnenberg & Vom Brocke, 2014, p.232). A process model can be easily assessed in its compliance to the economic reciprocity principle by identifying the increment and decrement types of economic events and by assigning them to transaction types. If those elements are missing, the process model does not contribute to any economic transaction at all. The authors used the coloured Petri-Net (CPN) formalism to implement the PAM. While CPN can accommodate to the economic reciprocity principle by modelling duality in increment and decrement transitions and places. If this modelling is done appropriate, the duality of economic events is forced by increment and decrement tokens in input places, i.e. by bi-directional relations. Consequently, the adherence to the economic reciprocity leads to economic consistency. A major drawback of the PAM concerning process modelling is the observation that it does not support the identification and classification of relevant business events and economic events, causing understandability problems between process managers and accountants.
2.2. **Workflow nets**

Martos-Salgado and Rosa-Velardo (2012) extend resource-constrained workflow Nets (rcwf-Nets) by introducing a priced version, called priced resource-constrained workflow Nets (prcwf-Nets). The prcwf-Nets extend the research on workflow nets with discrete prices concerning transition firing and place storage. This extension was required while it was observed that wf-Nets are inherent to non-determinism, causing instances to follow less convenient workflow paths by limited or locked resources, resulting in high (unnecessary) costs in most cases. To prevent non-determinism and unnecessary costs, the prcwf-Nets define priority or preference rules. One drawback is that the model fails to account for time in the context of storage cost calculations. Another drawback is the lack of empirical testing of the concept.

2.3. **S-BPM**

Zehbold, Schmidt and Fleischmann (2013) integrated the ABC technique (Section 5.2.1) into the subject-oriented Business Process Management (S-BPM) modelling language. Their framework aims to provide cost information about processes, in order to support the strategic and operational dimensions of process control, and pursue a continuous process improvement. In line with the ABC technique, they also use the concept of a cost driver. However, instead of determining different cost drivers they want to assign a major cost driver and allocate all other cost types proportionally in order to keep things simple. They state that in most cases the labour cost will turn out to be the major cost driver. However, the authors believe that the use of multiple cost drivers would still make the procedure easy to handle. The next step would be to assign the subjects to the elements of the current organizational structure. In combination with the duration data retrieved from event logs (by making use of time stamps) the total process duration can be determined and used to calculate the total process cost (Zehbold, Schmidt, & Fleischmann, 2013). One limitation of the presented framework is its particular application on people intensive areas with a high degree of indirect costs (like services). On the other hand, a great advantage of this framework is its characteristic to keep things simple and easy to use in practice on many different processes. Moreover, this framework would benefit from empirical testing.

2.4. **EPC**

Vom Brocke, Mendling and Recker (2010) use the Event-driven Process Chain (EPC) modelling language to identify and assess several consumption and usage factors as operational input in the process (Section 4.1). In this case, the EPC model functioned like a process disclosure tool. The research focussed on ways how the different payments of a process (instance) can be calculated fully or partitioned, according to different functions, schemas and keys. After those process (instance) payments are determined, they have to be aggregated for each specific process and each period within the planning-horizon. Generally, payments of all functions have to be added. In case of process branches in which an alternative processing takes place, the probability of branches has to be considered (Vom Brocke, Recker, & Mendling, 2010). Ultimately, this approach determines all relevant payments and receivables apparent in the process instances of the EPC model. A great benefit of this framework is that the process modelling practice does not only take into account the mere behavioural aspects of business operations, but also puts the design into the perspective of long-term financial consequences. However, this also causes the framework to focus on value
considerations during a process change initiative instead of value considerations during new process design, i.e. the focus of the current research. Lastly, this framework would benefit from more empirical testing.

2.5. BPMN

Four studies revealed extensions to the BPMN modelling language by including cost information. Magnani and Montesi (2007) extended BPMN by including cost considerations in the business process models. Their proposed extensions include specifying the cost of each element as a property (Figure 2.1a), specifying cost intervals for each element (Figure 2.1b) and specifying average cost for each element (Figure 2.1c).

Figure 2.1: BPMN extensions by Magnani and Montesi (2007). a) cost of each element as a property, b) cost intervals and c) average costs

The first concept (Figure 2.1a) has very limited applicability while it does not support other BPMN constructs. The other two types (Figure 2.1b and c) are defined by a homogeneous cost model and are able to support other BPMN constructs. They illustrated the applicability of the provided concepts in a ‘single-token independent process’, a ‘single-token independent process including sub processes’ and a ‘multi-token independent process including sub processes’. For all situations the maximum cost and overall cost of the whole process are calculated for both the cost interval, as well as, the average cost concept, except for the ‘multi-token independent process including sub processes’ situation, while only the average cost concept qualifies here for calculations. A great benefit of these concepts is that they define classes of diagrams for which the management of costs can be reduced to existing and well-studied problems. However, is yet does not take account of process branches, the factor of time and a lot of other BPMN constructs. It is also hardly tested in practice. An illustration of BPMN including the different extensions is shown below, considering the different scenarios.

Figure 2.2: A single-token independent process extended with cost intervals (Magnani and Montesi, 2007)
Sampath and Wirsing (2009) extend the research of Magnani and Montesi (2007) by adding the concept of reliability to the cost calculation of each task or activity. In this way the ‘Business Cost of the Process’ can be determined in a more reliable and accurate manner. However, all drawbacks already named for Magnani and Montesi (2007) are also present in this research. The concepts of Sampath and Wirsing (2009) are illustrated in series, parallel, and branch (alternative paths) processes.

Another research by Mueller-Wickop, Schultz, Gehrke and Nüttgens (2011) extends BPMN by introducing the BPMN-Finance notation. The aim of the BPMN-Finance notation is to address the lack of financial value-flows in traditional modelling languages. As a result, they provide a
visualization form which uses colours to identify financial types and is supported by process mining. The BPMN-based modelling notation is chosen while this modelling language is capable of integrating the financial- and process-dimension (Mueller-Wickop, Schultz, Gehrke, & Nüttgens, 2011). The authors believe the BPMN-Finance notation helps managers to shift to a more process-oriented-view, while it exposes the processes responsible for the financial entries in the organization. Next to that, it will also result in a better and faster understanding of the interdependencies and procedures within the accounting function by allowing an easier cognitive processing (Mueller-Wickop, Schultz, Gehrke, & Nüttgens, 2011, p.12). However, the BPMN finance notation does not take account of variable costs. Next to that, it focusses on the graphical display which means it does not show any calculations.

2.6. Conclusions

An overview of all the methods and concepts named in this section, together with their advantages and disadvantages, is displayed in Appendix I. The support of the concepts for the several types of financial information is presented in Table 2.1. As you can see, a lot of financial types are supported by the concepts (green checkmarks). However, there are only three concepts that support all types of financial information at once. In particular, it is observed that only one BPMN related concept supports overhead and all BPMN related concepts do not support variable financial information. Consequently, it is observed that the BPMN related concepts fail to support all types of financial information (at once).

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Table 2.1: Overview of Types of Financial Information in the methods and concepts
3. Research Design

This chapter consists of four sections. First, the research scope is described in Section 3.1. Second, the problem that initiated the current research is identified in Section 3.2. Third, the research goal and subsequent research questions are presented in Section 3.3. Finally, the research methodology is presented in Section 3.4.

3.1. Research Scope

The focus of this study is to design an approach which integrates financial information in a business process model and, subsequently, improves management decision-making. However, it would take too much time to research the design of an approach for all available business process modelling languages. Currently, the BPMN modelling language has the most potential and is emerging as a de facto standard language for capturing business processes (Allweyer, 2010; Chinosi & Trombetta, 2012; Fernández Fernández, et al., 2010; Vom Brocke, Recker, & Mendling, 2010). Moreover, BPMN is valued for its simplicity, standardization, interoperability and power of expression (Flowers & Edeki, 2013). Consequently, the current research will focus on the BPMN modelling language.

3.2. Problem Identification

The conceptual financial extensions to BPM modelling languages in earlier studies (Chapter 2) support several types of financial information. However, there are only three methods that support all types of financial information at once. Besides, those approaches are all yet not implemented in practice, or even not tested at all. As a consequence, all presented findings would benefit from empirical testing. Furthermore, they lack a prescription for the actual implementation into practice. In particular, the BPMN related concepts fail to support all types of financial information, since it does currently not support variable financial information. Next to that, it lacks a temporal perspective (Gagne & Trudel, 2009; Magnani & Montesi, 2007). In addition, a lot of BPMN constructs and their association with financial information is yet not considered in the selected literature.

3.3. Research Goal and Questions

Deduced from the research scope and problem statement, the research goal of this project is to ‘design an approach that describes how financial information should be determined and included in BPMN models in order to improve the decision-making of managers’. Eventually, the applicability of the approach has to be validated in a real-case in order to extend the current research. The main research question, which will be covered in the remainder of this project, is defined as follows:

“How can the presentation of BPMN models be extended with financial information in order to improve management decision-making?”

The following research questions are formulated in order to guide this research:

1. What operational financial process information exists?
2. Which BPMN elements are suited to present financial information in a business process model?
3. What is the best way to determine the financial information of individual elements in a BPMN model?
4. What financial information is important for management decision-making in a business process model?
3.4. Research Methodology

This section introduces the research methodology. The research methodology describes the steps which were performed in this research in order to answer the research questions and, subsequently, to achieve the research goal (Section 3.3). The fictional phone repair process of Nauta (2011) is used for illustration purposes throughout this research and, as a result, is translated to BPMN (Appendix III). The graphic representation of the research methodology is presented in Figure 3.1. The remainder of this section describes the research methodology in more detail.

**Step 1: Perform a literature research**

A thorough literature research was required in order to address the identified problems, to answer the research questions, and to achieve the research goal. This literature research provided the required information in order to answer research question one and to perform step 2 and 3.

*Output 1:* Available operational financial process information (Section 4.1)
*Output 2:* Properties of BPMN elements (Appendix II)
*Output 3:* Accounting techniques which allocate indirect financial information (Section 5.1)

**Step 2: Link financial information with BPMN elements**

This step examined which BPMN elements (can) have financial information associated and, as a result, are able to show financial information in a BPMN model. For this purpose, the properties of financial information and BPMN elements were outlined in tables and, subsequently, matched on similarities and compatibilities (in Section 4.2). At the end, research question two was answered (Section 4.2)

*Output:* Financial information is linked with BPMN elements (Section 4.2)

**Step 3: Determine the best technique to allocate indirect financial information**

This step examines which technique or method is best suited to determine the total cost (i.e. sum of direct and indirect cost) of individual elements in a business process. The literature research resulted in three potential techniques from the Management Accounting discipline which are able to allocate indirect costs to individual elements in a business process (Section 5.1). First, those techniques were compared based on literature (Section 5.2). Second, since the literature could not identify one single technique as the best for the research approach, the two most promising techniques were applied on the illustrative case (Section 5.2.1 and 5.2.2). At the end, one technique was chosen for the approach of this research which, subsequently, led to the answer to research question three (Section 5.2.3).

*Output:* Technique that is best suited to determine the total cost of individual elements in a business process (Section 5.2)

**Step 4: Determine which financial information is important for management decision-making**

The technique (resulted from step 3) contains a lot of (financial) information which should not all be displayed in a process model, while it would make the BPMN model messy and unreadable.
Obviously, a messy and unreadable model would reduce, rather than improve, the decision-making of managers. Therefore, it had to be determined which (financial) information is most important for the decision-making of managers and, as a result, should be shown in a BPMN model. In order to make a justifiable smaller selection of all the available (financial) information, four managers were surveyed by an individual questionnaire. The questionnaire is presented in Appendix V (in Dutch). Subsequently, the results of the questionnaires were analysed which led to the answer to research question four (Section 6.3).

**Output:** Important components of financial information for decision-making (Section 6.3)

### Step 5: Design approach (research goal)

This step integrated the output of the earlier steps and resulted in the design of a stepwise approach that describes how financial information should be determined and included in BPMN models in order to improve the decision-making of managers. After the approach was designed, the research goal was completed (Chapter 7).

**Output:** Approach that describes how financial information should be determined and included in BPMN models (Chapter 7)

### Step 6: Implement approach in a real-case

This step implemented the approach on a real-case in order to validate its applicability. The approach was implemented on the BPMN model of the DOE-MEE service product of the company Ploos Energieverlening (Section 8.3).

**Output:** The validation of the applicability of the approach in a real-case (Section 8.4)
Step 1: Perform a literature research

Output: Available operational financial process information

Research question 1 answered: Chapter 4

Step 2: Link financial information with BPMN elements

Output: Properties of BPMN elements

Output: Financial information is linked with BPMN elements

Research question 2 answered: Chapter 4

Step 3: Determine the best technique to allocate indirect financial information

Output: Accounting techniques which allocate indirect financial information

Output: Technique that is best suited to determine the total cost of individual elements in a business process

Research question 3 answered: Chapter 5

Step 4: Determine which financial information is important for management decision making

Output: Important components of financial information for decision-making

Research question 4 answered: Chapter 6

Step 5: Design approach (research goal)

Output: Approach that describes how financial information should be determined and included in BPMN models

Research goal achieved: Chapter 7

Step 6: Implement approach in a real-case

Output: The applicability of the approach in a real-case is validated

Approach validation: Chapter 8

Figure 3.1: Research Method
4. The link between financial information and BPMN elements

This chapter determines which BPMN elements have financial information associated and, consequently, should present financial information in a BPMN model. In the first section, the available operational financial process information, its types and its properties are described. The properties of BPMN elements are presented in the table of Appendix II. In the second section, the properties of financial information and BPMN elements are analysed and matched.

4.1. Financial Information

On the operational level the relevant payments associated with a specific process design are considered. This level distinguishes between payments (out-payments) and receivables (in-payments) (Vom Brocke, Recker, & Mendling, 2010). Another distinction is made on whether costs are caused directly or indirectly by a process, product or service. Those costs can be subdivided in variable, fixed and overhead. In the case of overhead, its allocation to individual process instances is currently not possible (Vom Brocke, Recker, & Mendling, 2010; Wynn, et al., 2013; Zehbold, Schmidt, & Fleischmann, 2013).

Costs are caused direct or indirect by a business process (instance). Direct costs can be identified with specific cost units, i.e. the effect of cost can be measured in respect of each particular unit of output (Atrill & McLaney, 2007, p.271). Those costs can be specifically and exclusively identified with a particular cost object (Drury, 2005, p.30). The main examples of direct costs are direct materials and direct labour. Indirect costs are all other costs that cannot be directly measured in respect of each particular unit of output and cannot be identified specifically and exclusively with a given cost object (Atrill & McLaney, 2007; Drury, 2005). The main examples of indirect costs are salaries (of indirect related employees to the cost object) and rent. It is very important to understand the difference between the nature of fixed and variable; and direct and indirect costs. The fixed and variable costs are concerned with cost behaviour in the face of changes in the volume of activity. Directness of cost, on the other hand, is concerned with collecting together the elements that make up full cost, that is, with the extent to which costs can be measured directly in respect of particular units of output or jobs. Although it may be true that there is a tendency for fixed costs to be indirect costs (overhead) and for variable cost to be direct costs, there is no link, and there are many exceptions to this tendency (Atrill & McLaney, 2007, p.274). Eventually, the total cost can be the sum of direct and indirect costs, but also the sum of fixed and variable costs. These two facts are independent of one another (Atrill & McLaney, 2007, p.275).

Variable costs have been traditionally used in accounting literature to describe how a cost reacts to changes in activity (Drury, 2005, p.34). They change practically every time a process is executed, caused by multiple factors in the process. Variable costs can be subdivided into consumption and usage cost factors. Factors of consumption are objects that are consumed by functions. The most prominent factors of consumption are the cost of goods (i.e. raw materials) and services (i.e. telephone or internet provider cost) (Sonnenberg & Vom Brocke, 2014; Vom Brocke, Recker, & Mendling, 2010; Wynn, Low, & Nauta, 2013; Wynn, Low, Ter Hofstede, & Nauta, 2014; Zehbold, Schmidt, & Fleischmann, 2013). Factors of usage are objects of input that serve as resources for processing a function. They can be calculated fully or partitioned according to ‘predefined keys’. The
most prominent factors of usage are labour, resource, external party and storage cost (Martos-Salgado & Rosa-Velardo, 2012; Vom Brocke, Recker, & Mendling, 2010; Wynn, Low, Ter Hofstede, & Nauta, 2014). Consumption and usage factors are constrained by their capacity. The labour costs are in most cases assumed to be the major cost element by accountants and depend on people, tasks and time (Zehbold, Schmidt, & Fleischmann, 2013).

The fixed costs remain constant over wide ranges of activity for a specified time period (Drury, 2005, p.34). They do not change every time a process is executed. Those costs are mainly caused by activity invocations, administration, equipment depreciation, leasing charges for cars, penalties and investments (Vom Brocke, Recker, & Mendling, 2010; Wynn, Low, Ter Hofstede, & Nauta, 2014; Wynn, et al., 2013). The distinction between fixed and variable costs must be made relatively to the time period under consideration. Over a sufficiently long time period of several years, virtually all costs are variable (Drury, 2005, p35).

Step fixed or semi-fixed costs are fixed within a capacity range of an activity. However, if the capacity of the activity exceeds the range, the fixed cost are affected (stepwise). In other words, the distinguishing feature of stepped fixed costs is that within a given time period they are fixed within specified activity levels, but they eventually increase or decrease by a constant amount at various critical activity levels (Drury, 2005, p.36). For example, a factory floor space provides sufficient room for the production facilities within a particular production volume and has a fixed rent per month. When the production is increased the current space in not sufficient anymore and an expansion is required, which has greater (new) fixed rent costs.

Semi-variable or mixed costs include both a fixed and variable component. The semi-variable cost of an activity can be caused by a fixed invocation cost and a subsequent variable cost depending on the level of activity. An example of semi-variable cost is an employees’ fixed salary plus a conditional bonus (Atrill & McLaney, 2007; Drury, 2005).

Overhead cost cannot be directly measured in respect of each particular unit of output. Sometimes, overhead is also called ‘common costs’ because they are common to all production of the production unit (Atrill & McLaney, 2007, p.271). Examples of overhead costs are interest rates, taxes, maintenance cost, training cost, support cost, location rent cost and other indirect but present cost in the business functions which are required to execute a process, i.e. administration, marketing, sales, distribution and IT (Vom Brocke, Recker, & Mendling, 2010).

The receivables of a process, on the other hand, are also divided into variable and fixed receivables. The variable receivables may dependent on multiple factors, like the number of time units, the number of output units, and the quality of the output unit. Those factors can be influenced by process’ risks and reliability (Bolsinger, Bewernik, & Buhl, 2011; Sonnenberg & Vom Brocke, 2014). The fixed receivables mostly result from (long- or short-term) contracts, imposed fines or interests.

An overview of all the cost factors, and its corresponding most illustrative examples, are presented in Table 4.1.
## 4.2. Establishing the link between BPMN Elements and Financial Information

As mentioned in the previous section, direct and indirect financial information can be variable or fixed; while overhead can only be indirect. The properties of variable, fixed and overhead financial types of information are presented in Table 4.2.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Drivers</th>
<th>Constraints</th>
<th>Change rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
<td>Consumption or use of resources</td>
<td>Time, people, tasks and number of (output) units</td>
<td>Capacity of resources</td>
</tr>
<tr>
<td><strong>Fixed</strong></td>
<td>Activities</td>
<td>Activity invocations</td>
<td>Only constant within a specified time period and/or capacity range of activity</td>
</tr>
<tr>
<td><strong>Overhead</strong></td>
<td>An organization or process</td>
<td>The cost of business functions that support a process indirectly</td>
<td>Cannot be directly measured in respect of each particular unit of output and cannot be identified specifically and exclusively with a given cost object</td>
</tr>
</tbody>
</table>

Table 4.2: Properties of financial types of information

From Table 4.2, some observations are made. Firstly, the factor of time is important for both variable and fixed types. While it drives variable cost or income; and limits the constancy of fixed cost and income (Section 4.1). Secondly, the capacity of resources or activities is an important
constraint for variable and fixed types. Thirdly, variable types can depend on people (resource), i.e. it depends on the characteristics (both financial and time) of a person who performs a task. However, instead of a person, it could also depend on the characteristics of a department, function or system which performs the task in an organization. Fourthly, the characteristics of a task (i.e. the type of resource required and the number of tasks performed in a period of time) are important for both variable and fixed types of financial information. Lastly, the more general term ‘number of output units’ enables the use of more specific drivers for specific tasks to calculate the variable costs or income.

As a result, it is concluded that the important drivers of financial information are:
- Amount of time (i.e. durations)
- type of resource and its capacity
- number of task invocations
- number of output units

The properties of overhead are yet not considered. While overhead is indirect and “cannot be directly measured in respect of each particular unit of output and cannot be identified specifically and exclusively with a given cost object” (Table 4.2). This means that a technique is required that can determine and allocate overhead (or indirect) costs of a process to a particular cost object. This issue is further addressed in Chapter 5.

An overview of the most important constructs used in the BPMN modelling language and their corresponding properties (based on: Chinosi & trombetta, 2012; Dijkman, Dumas, & Ouyang, 2008; Dumas, La Rosa, Mendling, & Reijers, 2013) are presented in Appendix II. The most basic concepts of BPMN are presented in the first column, i.e. event, activity, gateway, data element, resource and connecting object. The following links can be made between the types of financial information and the properties of the constructs of BPMN.

An event presents things that can happen instantaneously and cannot retain tokens. This means they do not have time durations associated and only function as a trigger in the process according to specified conditions or (internal and external) actions. Consequently, it is concluded that events do not have any of the important properties of financial information and, subsequently, events are not suited to represent financial information.

An activity presents a unit of work that has time duration, i.e. it retains a token for the time duration of its execution. Obviously, this concept involves time. Next to that, it is able to present how often it is initiated (i.e. number of task invocations) and to define its output (i.e. number of output units). This means that an activity is very suited to present financial information. Hence, it is also worth evaluating the suitability of the sub-constructs of a BPMN-activity with financial information. A task is an activity capturing a unit of work that cannot be further broken down, i.e. it has all properties of an activity. Therefore a task is very suited to present financial information. A send activity is an activity that is the source of a message. This means the same conclusion can be drawn as for a task, except that this activity adds a unit of output in the form of a message. A message is a variable cost factor of consumption (Section 4.1) and its cost (both physical and digital) should be easy to determine. A sub-process is a self-contained, composite activity that can be broken down into smaller units of work, i.e. it identifies activities which together achieve a particular goal or generate
a particular outcome. This means that a sub-process comprises not only tasks, but also other constructs. Nevertheless, while a sub-process includes activities and, therefore, financial information, it should be possible to determine the ‘total cost’ of a sub-process. A *multi-instance* activity is an activity (being it a task or a sub-process) that is executed multiple times concurrently for multiple entities or data items. As a result, this kind of activity has multiple task invocations concurrently before the process continues. While this again is an important property of financial information (i.e. number of task invocations), a multi-instance activity is very suited to present financial information.

A *gateway* presents a gating mechanism that either allows or disallows the passage of tokens through the gateway by merging input or splitting apart output. Gateways do not retain tokens and just redirect them according to predefined conditions or actions. However, when we consider the redirection of tokens according to actions, the distinction has to be made between internal and external actions, because external actions could imply costs associated with waiting time. When a gateway has to wait for the response of an external organization (for instance a customer), the token is not allowed to pass. This kind of gateway is called an ‘*Event-based exclusive (XOR) split*’. Its formal definition is that it determines the continuation of the process according to the first external event to occur. This type of gateway incurs waiting time and therefore costs. When this gateway is used in a process model, it portrays that the process will not continue until the external action is performed and, as a consequence, the resource will wait accordingly. However, in reality a resource will not ‘just’ wait for the external action to be performed, but will perform other tasks of his or her job instead. In other words, a resource is not really awaiting an external response and is performing other tasks instead. Anyway, someone should still check whether the external action is performed and act accordingly (i.e. send reminder). This control action portrays a task (or a set of tasks) and therefore time and costs. Hence, the costs associated with waiting time are captured in control actions (i.e. activities). Therefore, it is concluded that gateways are not suited to determine or represent financial information.

A *data element* indicates which data is required to perform an activity and which ones are produced as a result of performing an activity. They are, however, purely annotations to the process model and do not have any property in accordance with the financial information. Consequently, data elements are not suited to represent financial information.

A *resource* represents who or what performs which activity or, in other words, a variable cost factor of usage (Section 4.1). One important property of the financial information is the definition of resources. Hence, it is worth evaluating the suitability of the sub-constructs of an activity with financial information. A *pool* represents a resource class or participant, i.e. it is a referral to a group of resources that are interchangeable in the sense that any member of the group can perform a given activity. It only considers active resources (i.e. resources that can autonomously perform an activity). A *multi-instance pool* represents a set of resource classes, or resources, having similar characteristics. Those characteristics could, however, differ in cost characteristics and, if this is the case, should be considered separately. A *white box pool* shows the activities, events, gateways and data objects of the participating organization, in contrast to a *black box pool*, which does not. While the presence of activities is mainly required to determine and present financial information in a process, white box pools are suited and black box pools are not. A *swim lane* is a partition of a pool
into subclasses or single resources. A swim lane can present a participant’s role, but also a specific software system or equipment. Hence, a white box pool and its swim lanes are very suited to determine the resources of a process and, subsequently, obtain their associated capacity and costs.

A connecting object only describes the relationship between objects in the process model. It has no time associated or other properties that are important for financial information. Therefore, connecting objects are not suited to represent financial information.

To summarize, the properties of the following BPMN elements are compatible with the important drivers of financial information and, therefore, are suited to determine and represent financial information in a BPMN model: task, send activity, sub-process, multi-instance activity and swim lane (in a white box pool). Consequently, the properties of events, gateways, data elements, connecting objects and black box pools are not compatible with the important drivers of financial information and, therefore, are not suited to present financial information in a business process model.
5. The determination of direct and indirect financial information in a business process

This Section describes the determination of both the direct and indirect costs of elements in a business process. As mentioned in Section 4.1, the major problem of indirect costs (or overhead) is that they cannot be easily assigned to an individual process element. The Management Accounting discipline developed several techniques to overcome this problem. Those techniques are described in section 5.1. Next, Section 5.2 compares the accounting techniques and, subsequently, concludes which technique is best to determine the direct financial information and allocate the indirect financial information to individual elements in a BPMN model.

5.1. Indirect cost allocation techniques

The indirect financial information (or overhead) cannot be assigned to individual activities and resources in the business process. Significant indirect (or overhead) costs of businesses are caused by business functions, i.e. administration, marketing, sales, distribution and IT, which are inevitably needed in order to operate a business appropriately (Zehbold, Schmidt, & Fleischmann, 2013). As a result, techniques were required to account for both direct and indirect costs and allocate them directly to a product, a service or another element in a business process in order to support more accurate decision-making. Therefore, a common but distinct property must be observed and measured among the cases, which provides a reasonable basis for distinguishing between one case and the next (Atrill & McLaney, 2007). In other words, a suitable overhead absorption rate for the business as a whole is required. One could say that it is probably reasonable to take the view that the nature of the overhead should influence the choice of the basis of charging overhead to jobs (Atrill & McLaney, 2007, p.280). As a simple illustration, manufacturing companies would probably prefer an allocation based on machine hours, while a service company would rather prefer an allocation based on direct labour hours. It should, however, be stressed that there exists no such thing as ‘the best allocation rate’, while this choice is just a matter of judgement. The Management Accounting discipline developed several techniques to overcome this problem: Activity-Based Costing (ABC), Time-Driven ABC (TDABC), and Resource Consumption Accounting (RCA) (Nauta, 2011; Thabet, Ghannouchi, & Ghézala, 2014; Wynn, Low, Ter Hofstede, & Nauta, 2014). Yet, the use of an accounting technique in combination with a BPMN model will not only benefit the BPM discipline. Since the integration will allow the BPM and Management Accounting disciplines to make use of each other’s benefits, while BPM models identify all individual activities that take place in a system, from the beginning to the end, in a more accurate way than the methods used in the management accounting discipline (Hadzilias, 2005). Next to that, BPM models greatly help to reduce time used for modelling and overcome the difficulties present in creating the cost models in Management Accounting. The accounting techniques are now further described in the subsections below.

5.2.1. Activity-Based Costing

The ABC-technique considers the per activity unit cost of all possible activities (Wynn, Low, Ter Hofstede, & Nauta, 2014, p.407) and comprises a two-stage allocation process. In the first stage, it identifies the major activities within an organization and assigns indirect costs to cost pools for each activity. In the second stage, it determines an activity-cost driver for each major activity and assigns...
the cost of activities to products according to the product’s demand for activities (Atrill & McLaney, 2007; Drury, 2005, p.377; Szychta, 2010). The cost pools emerge on the basis of cause-and-effect of resource-cost drivers, time logs, direct observation or interviews with staff that can provide reasonable estimates of the resources consumed by different activities (Kaplan & Anderson, 2003). The activity cost drivers can be either volume-based or non-volume-based. Volume-based means that the overhead costs consumed are assumed to have a high correlation with the number of units produced (Drury, 2005). Typical examples of volume-based cost drivers are units of output, direct labour hours and machine hours. Subsequently, these cost drivers are appropriate for measuring the consumption of expenses (i.e. machine energy, depreciation, indirect labour). Conversely, non-volume-based cost drivers are not performed for each unit of output. One typical example of a non-volume-based cost driver is the number of set-ups. Adopting ABC requires that the overhead can be analysed and cost drivers can be identified. The implementation of ABC will lead to a much clearer insight in the causes of overhead costs, activity by activity. This will also lead to the accurate identification and control of process, product or service costs (Atrill & McLaney, 2007, p.292; Szychta, 2010). It will also provide information relevant both to long-term, strategic business management and to operational management (Szychta, 2010). In addition, ABC integrates the efforts of value analysis, process analysis, quality management and costing into one analysis (Szychta, 2010). Several process management and modelling tools such as ARIS, WizdomWorks!, Provision EnterprisePro, or Proforma include ABC as part of their business process analysis features (Vom Brocke, Recker, & Mendling, 2010).

ABC was at first developed for the manufacturing industry. However, service companies are even better candidates for ABC because, in the absence of a direct materials element, its total costs are likely to be particularly affected by overhead (Atrill & McLaney, 2007; Drury, 2005; Szychta, 2010). In addition, service organizations do supply most of their resources in advance and the fluctuations in the usage of resources by services or customers do not influence short-term spending to supply the resources (Drury, 2005, p.390); which makes the use of ABC even more appropriate. One major difference is that the service entities have to take customer behaviour into account in contrast to manufacturing companies. While many expenses of service companies are caused by demands by individual customers rather than by the service demands (Szychta, 2010, p.51).

One major drawback is the significant effort required to implement and update ABC (Atrill & McLaney, 2007; Horngren, Datar, & Foster, 2006; Szychta, 2010). Since, it requires periodically re-estimation through a new round of interviews and surveys to reflect changes in the company’s operations, after its initial implementation. It also needs entirely new cost estimations when new activities are added to the model or when estimations (of cost pools) have changed (Szychta, 2010; Tse & Gong, 2009). As an illustration of this problem: an ABC system at a large financial services firm required fourteen full-time people just to collect and process the data and prepare management reports which took more than thirty days to prepare (Szychta, 2010). Consequently, ABC models are often not maintained and their cost estimates soon become obsolete. This drawback formed a major barrier to the widespread adoption of ABC (Kaplan & Anderson, 2003; Szychta, 2010). Next to that, the ABC tends to define complex, granular activities as single activities in the process model. Those single activities are abstractions of reality and make the costing technique less accurate (Atrill & McLaney, 2007; Kaplan & Anderson, 2003). Besides, ABC tends to use past (historic) costs and
subjective data (recall of time allocations to tasks by employees) which is difficult to validate and therefore makes it even less accurate (Atrill & McLaney, 2007; Kaplan & Anderson, 2003; Szychta, 2010). Moreover, the ABC does not take account of variations in the same activity (Szychta, 2010; Wynn, Low, Ter Hofstede, & Nauta, 2014; Zehbold, Schmidt, & Fleischmann, 2013). Finally, it should consider practical capacity instead of the actual capacity. Employees generally overstate their downtime and time spent unproductively during work hours, in spite of the fact that they cannot work as a machine all day (Kaplan & Anderson, 2003; Szychta, 2010). All these drawbacks led to the observation that the vast majority of ABC implementations did not sustain the long-run and the adoption rate of ABC in business organizations is very low (Szychta, 2010; Tse & Gong, 2009).

Nevertheless, Kaplan and Anderson (2003) observed that ABC works well in the limited setting in which it was initially applied, typically a single department, plant or location. They also observed that many of the initial studies were one-time events that provided a useful snapshot of the plant’s current economics, such as to identify high cost, inefficient processes and the unprofitable products and customers. They state that even today, the revelation of high cost processes, products and customers stimulates near-term actions (activity-based management) that can lead to near-term and often dramatic profit improvements (Kaplan & Anderson, 2003, p.3). In addition, Szychta (2010) states that ABC has a value-creation potential much exceeding the costs of its implementation and maintenance owing to generation of useful information guiding decisions made in large organizations by thousands of people, in many divisions, and relating to huge numbers of products, process, customers and transactions (Szychta, 2010, p.58).

5.2.2. Time-Driven Activity-Based Costing

The TDABC is especially designed to simplify implementation and maintenance of cost management systems. It considers the per time unit cost of all possible activities (Kaplan & Anderson, 2003; Szychta, 2010; Tse & Gong, 2009; Wynn, Low, Ter Hofstede, & Nauta, 2014). Instead of assigning cost to individual products or services like ABC, TDABC calculates and assigns a time frame and cost per time unit. TDABC removed activity pools and instead defines resource-activity drivers, which capture in a detailed way how resources are involved in activities for the purpose of delivering a specific product or service. It defines all measurements in time units (Szychta, 2010). Hence, TDABC only requires estimates of the capacity of the committed resources, their cost rates, and the activity duration. The time estimates can be obtained either by direct observation or by interviews (Szychta, 2010). Precision is not critical; rough accuracy is sufficient (Kaplan & Anderson, 2003). It also offers the possibility to define resource drivers for activities that approximately require the same amount of time (i.e. the tasks setup machine, issue purchase order or process customer request all make use of the resource ‘labour’ of a particular function or department) and saves design time of a cost system (Kaplan & Anderson, 2003; Szychta, 2010). Consequently, TDABC is simpler, less costly, more accurate, more valid and faster to implement (Tse & Gong, 2009), and allows cost driver rates to be based on the practical capacity of the resources supplied (Kaplan & Anderson, 2003, p.5). Consequently, it is stated that TDABC succeeds to deal with all limitations of ABC (Kaplan & Anderson, 2003; Szychta, 2010; Wynn, Low, Ter Hofstede, & Nauta, 2014).

The practical capacity of a resource is often estimated as 80% of technical capacity. In this way the cost system allows personnel to take time for a break, arrival and departure and other non-work-
related tasks and takes account of the down-time of a machine due to maintenance, repair and scheduling fluctuations. This estimation will not significantly affect the cost calculations if it is approximately (5-10%) right (Kaplan & Anderson, 2003; Szychta, 2010).

Service organizations with large proportions of human and IT resources and standardized operating activities are likely to benefit most from the model as time is an appropriate common measure of resources for this type of organizations (Tse & Gong, 2009, p.52). Also, the use of time equations is particularly suitable in service companies and in service and supporting functions in manufacturing enterprises (Szychta, 2010, p.55). Indeed, Szychta (2010) observed several cases in which service companies successfully implemented the TDABC costing model.

TDABC also allows for more heterogeneity in activities, orders and customer behaviour and eases the calculation of activity and product cost (Kaplan & Anderson, 2003). It can calculate different processing times for various types of orders by using time equations. For instance, a product can be a standard, extra or premium edition and, in most cases, more processing time (and consequently processing costs) is required in correspondence with the luxury level of the product. Those time equations make it no longer necessary to define separate activities for every separate product type, but instead estimates the resource demand by an equation which contains a minimum amount of time required (standard product) and an increment amount of time depending on the type of product; while it also takes account of the process’ capacity (Kaplan & Anderson, 2003; Szychta, 2010). The use of time equations makes TDABC more accurate in effectively addressing complex costing issues in comparison to the ABC formula (Szychta, 2010). Next to that, the TDABC model can easily be updated according to changes in company operations. In the case of new activities, a manager simply estimates the activity’s required time and adds it to the cost model. In the case of resource price changes, a manager must change the hourly resource cost rate accordingly. Another benefit of TDABC is the knowledge it generates about the efficiencies (unit cost and unit times) of critical business processes (Kaplan & Anderson, 2003, p.10). This knowledge helps managers to identify inefficient processes and initiate their improvement efforts. For instance, a manager could take action to relieve bottlenecks expected to persist in future periods, or act to reduce capacity in departments where any unused capacity was expected to persist for several periods into the future. Consequently, the re-estimation of the model shifts from a periodic nature to an events-based nature, i.e. re-estimation is performed when managers (or analysts) improved a business operation which affects aspects of the cost model (Kaplan & Anderson, 2003). Finally, it must be noted that TDABC systems seamlessly integrate with data of currently available ERP and CRM systems.

One drawback of TDABC is the fact that its calculations are largely based on estimates made by managers (Szychta, 2010). In the case of too arbitrary estimates, activity cost calculations may significantly differ from reality and misinform manager’s decision-making. Next to that, cost calculations in TDABC may also be distorted by time estimations of service activities, while a service activity has an unstable and irregular nature (Szychta, 2010). Finally, Wynn et al. (2014) and Sonnenberg & Vom Brocke (2014) state that TDABC is hardly used in practice, in contrast with the earlier statement of Szychta (2010), who observed several successful implementations of TDABC.
5.2.3. Resource Consumption Accounting

The RCA technique considers per unit cost of the resources that are involved in process execution (Wynn, Low, Ter Hofstede, & Nauta, 2014, p.407). The RCA model combines features of German costing models such as resource-focused cost management and quantity-based cost modelling with the activity-based paradigm and can be viewed as an evolution of the ABC model in ERP systems (Tse & Gong, 2009, p.42). It requires additional information on organizational resources and cost behaviour of all resources, i.e. variable and fixed components of resources and their corresponding consumption rates are required (Tse & Gong, 2009). In line with TDABC, RCA adheres to a resource-perspective which enables managers to determine and control the over- and underutilization costs of resources (Wynn, Low, Ter Hofstede, & Nauta, 2014, p.408). In contrast, the RCA costing technique provides more ways of allocating cost through direct allocation and the use of responsible managers and cost types, instead of primarily focussing on the allocation of resources’ costs to products and services by the ABC and TDABC costing techniques. RCA also sets itself apart by allowing both variable and fixed cost types in cost pools and the concurrent use of both activity-based and volume-based cost allocation methods. In addition, the consumption of resources in RCA in not solely based on time spent on operating activities (TDABC), but takes account of multiple drivers. Those differences cause the RCA costing model and their calculations of the cost of idle resources to be significantly different from the other costing models (Tse & Gong, 2009).

It should be emphasized that, unlike the TDABC model, the RCA model is not designed to reduce complexity of cost management systems and heavily depends on the integration with ERP systems to manage complexity (Tse & Gong, 2009, p.42). As a result, RCA is more suitable to manufacturing organizations which handle multiple heterogeneous resources in their operations (Tse & Gong, 2009).

5.2. The total cost of individual elements in a business process

As mentioned in Section 4.1, the total cost is the sum of direct and indirect financial information. This section explains how both components can be determined for individual elements in a business process.

The direct financial information of an individual activity or resource in a business process can be best determined by a cost recording system that is capable of capturing cost of direct materials used on each job and the cost, based on the hours worked and the rate of pay, of direct workers (Atrill & McLaney, 2007, p.271). According to Drury (2005): “cost assignment merely involves the implementation of suitable clerical procedures to identify and record resources consumed by cost objects” (Drury, 2005, p.61). He recommends the use of source documents to determine direct costs. The source documents ‘time sheets’ and ‘job cards’ are most appropriate to determine the direct labour costs, while they record the exact time spent on providing a service to a specific customer, or manufacturing a specific product. Next to that, the source document ‘materials requisition’ is more appropriate for the determination of direct materials costs, while it records the details of materials issued for manufacturing a product, or providing a specific service. Also, the use of bar coding and other forms of on-line information recording to determine direct costs is observed by many organizations (Drury, 2005). Hence, it is clear that direct costs determination has a lot of automation opportunities which can minimize the information gathering effort and, at the same
time, make information more accurate. Information systems and their (historic) data records are able to provide great assistance in this area. However, not all companies (especially the smaller ones) own such systems (Hadarra & Zach, 2011). Those companies can use other ways to determine the direct costs of an activity or resource in a business process. They could analyse their financial company data by making use of graphs. A graphical display of data enables, for example, the determination of the line of best fit to disclose variable and fixed cost information. Instead, statistical techniques (i.e. least squares regression) could be performed which usually provide better estimates. However, Atrill and McLaney (2007) state that it makes little difference which of these approaches is applied in practice. The direct costs could also be determined by interviewing process actors or by observing process activities and their use of resources or other input. Obviously, those efforts require a lot of time and the obtained information is much more subjective and sensitive to become outdated. A periodic re-assessment of the information would prevent it to become outdated, but would again require a lot of effort. In the case of a new product or service there is no (historical) information recorded yet and the use of these more intensive methods to acquire the direct (financial) information is inevitable. Nevertheless, a company should always strive to automate the determination of direct financial information as much as possible.

The determination of indirect financial information of an entire business process can be done in the same ways as mentioned for direct financial information. However, an accounting technique is required in order to allocate the indirect financial information (or overhead) to individual elements of a BPMN model, i.e. to allocate overhead to individual activities or resources in a business process. In the remainder of this section, the accounting techniques from the previous section are compared and analysed in their usability with BPM models in the current research.

ABC was the first technique to allocate indirect (or overhead) costs to single activities in a process. However, it is clear from Section 5.2.1, that the ABC costing model also has a lot of severe limitations. In the attempt to resolve these issues, TDABC and RCA were developed (Szychta, 2010; Tse & Gong, 2009). Those techniques resolved the major limitation of (unconsidered) idle resources in ABC (which caused inefficiencies in a process) through the provision of practical (i.e. realistic) information on (idle) resources in resource pools. It also simplified the cost analysis by changing from a collective to an individual cost analysis. In this way, cost models can be easily updated by adding or removing cost pools and activities without affecting other cost objects in the model. As a consequence, those techniques provide more relevant and reliable cost information for decision-making (Tse & Gong, 2009).

The TDABC and RCA models differ in some important aspects and an overview is presented in Table 5.1. Firstly, the calculations of idle resource costs are significantly different in the TDABC and RCA model. The difference lies in the determination of the consumption of resources, while TDABC solely considers the time spent on operating activities, whereas RCA also considers multiple drivers. Secondly, unlike TDABC, RCA is not designed to reduce complexity and aims to manage complex cost management systems (Tse & Gong, 2009). As a consequence, it is heavily dependent on the integration with ERP systems in order to obtain its required information (Tse & Gong, 2009). Next to that, TDABC is largely dependent on subjective estimates (made by managers), which makes the TDABC model less accurate than the RCA model. As a result of all above mentioned properties, RCA is particularly suited for manufacturing organizations and large companies with a lot of
heterogeneous resources and a well-integrated ERP system. Then again, TDABC should be better suited for service organizations, while service organizations implement, in general, not company-wide, but only parts of an ERP system (Botta-Genoulaz & Millet, 2006). Besides, service organizations, with large proportions of human and IT resources and standardized operating activities, are likely to benefit most from the model as time is an appropriate common measure of resources. Next to that, small and medium enterprises (SMEs) also make less use of ERP systems, mainly because of the high implementation costs and insufficient (short-term) returns (Hadarra & Zach, 2011). From this information, no strong conclusion could yet be drawn on whether the TDABC or the RCA technique is best suited to have a link with a BPMN model. Therefore, the following two subsections apply both techniques on the telephone repair process (Appendix III) separately. The conclusion is presented in Section 5.2.3.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Total cost</th>
<th>Technical capacity (hours)</th>
<th>Practical capacity (hours)</th>
<th>Cost per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester costs</td>
<td>€ 2.400</td>
<td>240</td>
<td>192</td>
<td>€ 12,50</td>
</tr>
<tr>
<td>Simple solver costs</td>
<td>€ 1.440</td>
<td>120</td>
<td>96</td>
<td>€ 15,00</td>
</tr>
<tr>
<td>Complex solver costs</td>
<td>€ 2.400</td>
<td>120</td>
<td>96</td>
<td>€ 25,00</td>
</tr>
<tr>
<td>Depreciation</td>
<td>€ 1.500</td>
<td>320</td>
<td>320</td>
<td>€ 2,19</td>
</tr>
<tr>
<td>Energy</td>
<td>€ 2.240</td>
<td>N.A.</td>
<td>N.A.</td>
<td>€ 0,00</td>
</tr>
</tbody>
</table>

Table 5.2: Resource costs per hour calculation

5.2.1. The application of TDABC in a process model

In this section is the actual application of TDABC in a process model is described. The phone repair process (Appendix III) is used for this illustration for the time period of a month. First, the resource costs per hour have to be calculated. In order to do this, the total cost per period and the capacity are required. It is advised to use the practical capacity (80% of technical capacity) in the calculations. In this way the cost system allows personnel to take time for a break, arrival and departure and other non-work-related tasks; and it takes account of the down-time of a machine due to maintenance, repair and scheduling fluctuations. The phone repair process has five resources of which: three are people, one is the depreciation of the used equipment and one is the energy consumption of the company (Table 5.2). The total cost of a resource is divided by the capacity of the resource, which results in the resource cost per hour. The labour resources’ capacities are calculated according to a workweek of 40 hours during a month (i.e. four weeks). The capacity of the equipment is calculated for two machines operating 40 hours in a week. The energy capacity is based on the total time of the activities in the process, while it does not constraint the current illustration.

Table 5.1: Comparison of features of TDABC and RCA
Secondly, the activity times have to be determined. In order to do this, all activities within a process model have to be represented. Next, the unit of activity has to be determined for each activity (i.e. number of activity invocations), together with its associated time consumption. Subsequently, the total time consumed by an activity can be determined and is illustrated in Table 5.3. The phone repair process is a service and, therefore, in this case all units of activities are units of invocations.

Thirdly, the allocation of indirect costs to single tasks can begin. Obviously, the allocation is based on total time. Bear in mind, that the indirect resource costs are only allocated to an activity that actually consumes the resource. For overview, one could determine the interdependencies between resources and tasks in a graphical model. In the case of the phone repair process, the allocation is based on five resources which results in five different allocations. The allocation of the tester costs are shown in Table 5.4 and the allocation of the other resources’ costs are presented in Appendix IV.

Fourthly, now the costs are allocated to the activities, they can also be presented in a BPMN model. They can be summed up with the direct costs of activities (Section 5.2) in order to obtain the total cost of an activity (Section 4.1). In addition, the cost determination of idle resources can support the decision-making of managers in order increase the efficiency of a process. As a result, a manager could decide to reduce, increase, remove or replace resources according to their idle costs. The cost calculations of idle resources in the phone repair process are presented in Table 5.5.

As can be seen from Table 5.5, the capacity of the simple solver (practical) is insufficient in the process (- €81,00). Next to that, the two machines do not have sufficient capacity to repair 370 phones in one month resulting in a negative monetary amount as idle resource cost (- €296,33). The cost of the idle resource energy is not shown, since its capacity does not constrain the current illustration and, as a result, the utilization of this resource will always be optimized. Lastly, the tester and complex solver resources have idle resource costs of €185,41 and €132,50 respectively, which means those resources’ workloads are not optimized in the current situation.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Number of units</th>
<th>Total time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>0,03</td>
<td>370</td>
<td>12,21</td>
</tr>
<tr>
<td>Inform customer</td>
<td>0,02</td>
<td>370</td>
<td>6,29</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>0,30</td>
<td>370</td>
<td>111,00</td>
</tr>
<tr>
<td>Simple repair</td>
<td>0,30</td>
<td>338</td>
<td>101,40</td>
</tr>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td>90,70</td>
</tr>
<tr>
<td>Determine issue</td>
<td>0,05</td>
<td>95</td>
<td>4,75</td>
</tr>
<tr>
<td>Repair screen</td>
<td>0,90</td>
<td>52</td>
<td>46,80</td>
</tr>
<tr>
<td>Repair case</td>
<td>0,60</td>
<td>42</td>
<td>25,20</td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td>0,45</td>
<td>31</td>
<td>13,95</td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>0,05</td>
<td>401</td>
<td>20,05</td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>0,02</td>
<td>31</td>
<td>0,53</td>
</tr>
<tr>
<td>Restart repair</td>
<td>0,05</td>
<td>31</td>
<td>1,55</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>0,02</td>
<td>372</td>
<td>6,54</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>0,10</td>
<td>42</td>
<td>4,20</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>0,04</td>
<td>370</td>
<td>14,80</td>
</tr>
<tr>
<td>Total time</td>
<td></td>
<td></td>
<td>369,27</td>
</tr>
</tbody>
</table>

Table 5.3: Activity times calculation
<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Resource activity driver</th>
<th>Unit of activity</th>
<th>Cost allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>0,03</td>
<td>€ 0,41</td>
<td>370</td>
<td>€ 152,63</td>
</tr>
<tr>
<td>Inform customer</td>
<td>0,02</td>
<td>€ 0,21</td>
<td>370</td>
<td>€ 78,63</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>0,30</td>
<td>€ 3,75</td>
<td>370</td>
<td>€ 1.387,50</td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>0,05</td>
<td>€ 0,63</td>
<td>401</td>
<td>€ 250,63</td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>0,02</td>
<td>€ 0,21</td>
<td>31</td>
<td>€ 6,59</td>
</tr>
<tr>
<td>Restart repair</td>
<td>0,05</td>
<td>€ 0,63</td>
<td>372</td>
<td>€ 19,38</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>0,02</td>
<td>€ 0,25</td>
<td>372</td>
<td>€ 81,75</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>0,10</td>
<td>€ 1,25</td>
<td>42</td>
<td>€ 52,50</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>0,04</td>
<td>€ 0,50</td>
<td>370</td>
<td>€ 185,00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>€ 2.214,59</td>
</tr>
</tbody>
</table>

Table 5.4: Allocation of tester costs to activities

<table>
<thead>
<tr>
<th>Resource</th>
<th>Committed cost</th>
<th>Allocated cost</th>
<th>Cost of idle resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester</td>
<td>€ 2.400</td>
<td>€ 2.214,59</td>
<td>€ 185,41</td>
</tr>
<tr>
<td>Simple solver</td>
<td>€ 1.440</td>
<td>€ 1.521,00</td>
<td>- € 81,00</td>
</tr>
<tr>
<td>Complex solver</td>
<td>€ 2.400</td>
<td>€ 2.267,50</td>
<td>€ 132,50</td>
</tr>
<tr>
<td>Depreciation</td>
<td>€ 1.500</td>
<td>€ 1.796,33</td>
<td>- € 296,33</td>
</tr>
</tbody>
</table>

Table 5.5: Summary of resource costs allocations

5.2.2. The application of RCA in a process model

The actual application of RCA in a process model is described in this section. The phone repair process of Nauta (Appendix III) is again used as an illustration for the time period of a month. RCA requires additional information on organizational resources and cost behaviour of all resources, i.e. it requires variable and fixed components of resources and their corresponding consumption rates. The variable cost, fixed cost, unit of usage, and unit of usage cost of resources are presented in a resource pool (Table 5.6).

<table>
<thead>
<tr>
<th>Resource pool</th>
<th>Fixed cost</th>
<th>Variable cost</th>
<th>Unit</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester costs</td>
<td>€ 0,00</td>
<td>€ 2.400,00</td>
<td>Labour hour</td>
<td>€ 12,50</td>
</tr>
<tr>
<td>Simple solver costs</td>
<td>€ 0,00</td>
<td>€ 1.440,00</td>
<td>Labour hour</td>
<td>€ 15,00</td>
</tr>
<tr>
<td>Complex solver costs</td>
<td>€ 0,00</td>
<td>€ 2.400,00</td>
<td>Labour hour</td>
<td>€ 25,00</td>
</tr>
<tr>
<td>Machinery</td>
<td>€ 800,00</td>
<td>€ 700,00</td>
<td>Machine hour</td>
<td>€ 2,19</td>
</tr>
<tr>
<td>General Company expenses</td>
<td>€ 2.400,00</td>
<td>€ 0,00</td>
<td>Number of phones</td>
<td>€ 0,00</td>
</tr>
</tbody>
</table>

Table 5.6: Resource pool

The machinery and general company fixed and variable costs are derived from the depreciation costs and energy costs in TDABC, respectively. Next to that, the consumption of resources in RCA can be based on more drivers than just time. The unit consumption rate of the resources is presented in Table 5.7. The consumption units in hours are the same as in TDABC. From this additional information, the fixed costs and variable costs of a resource can be allocated to activities. To determine the fixed costs of an activity, the fixed costs are divided by the total of activity consumption units and, subsequently, this cost rate must be multiplied with the particular amount of consumption of a particular activity. The variable costs must be determined by multiplying their unit cost with the particular amount of consumption of a particular activity. After these calculations, the sum of the variable and fixed cost of an activity can be represented (Table 5.8).
<table>
<thead>
<tr>
<th>Resource pool</th>
<th>Tester</th>
<th>Simple solver</th>
<th>Complex solver</th>
<th>Machinery</th>
<th>General Company cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>12,21</td>
<td></td>
<td></td>
<td></td>
<td>12,21</td>
</tr>
<tr>
<td>Inform customer</td>
<td>6,29</td>
<td></td>
<td></td>
<td></td>
<td>6,29</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
<td>111</td>
</tr>
<tr>
<td>Simple repair</td>
<td></td>
<td>101,40</td>
<td>101,40</td>
<td></td>
<td>101,40</td>
</tr>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine issue</td>
<td>4,75</td>
<td>4,75</td>
<td>4,75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair screen</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair case</td>
<td>25,20</td>
<td>25,20</td>
<td>25,20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td></td>
<td>13,95</td>
<td>13,95</td>
<td></td>
<td>13,95</td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>20,05</td>
<td></td>
<td></td>
<td></td>
<td>20,05</td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>0,53</td>
<td></td>
<td></td>
<td></td>
<td>0,53</td>
</tr>
<tr>
<td>Restart repair</td>
<td>1,55</td>
<td></td>
<td></td>
<td></td>
<td>1,55</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>6,54</td>
<td></td>
<td></td>
<td></td>
<td>6,54</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>4,20</td>
<td></td>
<td></td>
<td></td>
<td>4,20</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>14,80</td>
<td></td>
<td></td>
<td></td>
<td>14,80</td>
</tr>
<tr>
<td>Total</td>
<td>177,12</td>
<td>101,40</td>
<td>90,70</td>
<td>212,15</td>
<td>369,27</td>
</tr>
</tbody>
</table>

Table 5.7: Consumption of resources

<table>
<thead>
<tr>
<th>Resource pool</th>
<th>Tester</th>
<th>Simple solver</th>
<th>Complex solver</th>
<th>Machinery</th>
<th>General Company cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>€ 152,63</td>
<td></td>
<td></td>
<td></td>
<td>€ 74,07</td>
<td>€ 226,69</td>
</tr>
<tr>
<td>Inform customer</td>
<td>€ 78,63</td>
<td></td>
<td></td>
<td></td>
<td>€ 38,16</td>
<td>€ 116,78</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>€ 1,387,50</td>
<td></td>
<td></td>
<td></td>
<td>€ 673,33</td>
<td>€ 2,060,83</td>
</tr>
<tr>
<td>Simple repair</td>
<td>€ 1,521,00</td>
<td>€ 604,18</td>
<td>€ 615,10</td>
<td></td>
<td>€ 2,740,28</td>
<td></td>
</tr>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>€ 3,358,12</td>
<td></td>
</tr>
<tr>
<td>Determine issue</td>
<td>€ 118,75</td>
<td>€ 28,30</td>
<td>€ 28,81</td>
<td></td>
<td>€ 175,87</td>
<td></td>
</tr>
<tr>
<td>Repair screen</td>
<td>€ 1,170,00</td>
<td>€ 278,85</td>
<td>€ 238,89</td>
<td></td>
<td>€ 1,732,75</td>
<td></td>
</tr>
<tr>
<td>Repair case</td>
<td>€ 630,00</td>
<td>€ 150,15</td>
<td>€ 152,87</td>
<td></td>
<td>€ 933,02</td>
<td></td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td>€ 348,75</td>
<td>€ 83,12</td>
<td>€ 84,62</td>
<td></td>
<td>€ 516,49</td>
<td></td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>€ 250,63</td>
<td>€ 119,47</td>
<td>€ 121,62</td>
<td></td>
<td>€ 491,72</td>
<td></td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>€ 6,59</td>
<td></td>
<td></td>
<td></td>
<td>€ 3,20</td>
<td>€ 9,78</td>
</tr>
<tr>
<td>Restart repair</td>
<td>€ 19,38</td>
<td></td>
<td></td>
<td></td>
<td>€ 9,40</td>
<td>€ 28,78</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>€ 81,75</td>
<td></td>
<td></td>
<td></td>
<td>€ 39,67</td>
<td>€ 121,42</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>€ 52,50</td>
<td></td>
<td></td>
<td></td>
<td>€ 25,48</td>
<td>€ 77,98</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>€ 185,00</td>
<td></td>
<td></td>
<td></td>
<td>€ 89,78</td>
<td>€ 274,78</td>
</tr>
<tr>
<td>Total</td>
<td>€ 2,214,59</td>
<td>€ 1,521,00</td>
<td>€ 2,267,50</td>
<td>€ 1,264,08</td>
<td>€ 2,240,00</td>
<td>€ 9,507,17</td>
</tr>
</tbody>
</table>

Table 5.8: Allocation of resource costs to activities

Also, the total resource cost can be determined from Table 5.8. This cost information is, again, required to determine the cost of idle resources (Table 5.9). From Table 5.9, it is observed that the capacity of the simple solver is still insufficient in the process (~ € 81,00). However, the capacity of the two machines is now sufficient (~€235,92) according to the RCA calculations for the same situation. The idle cost of the other two resources is the same as in the TDABC calculation. Next to that, the cost of the idle resource energy is not shown, since its capacity does still not constrain the
current illustration and, as a result, the utilization of this resource will always be optimized. According to Tse & Gong (2009), RCA has the better estimates of resources’ idle capacity cost.

<table>
<thead>
<tr>
<th>Resource pool</th>
<th>Committed cost</th>
<th>Allocated cost</th>
<th>Cost of idle resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester costs</td>
<td>€ 2.400,00</td>
<td>€ 2.214,59</td>
<td>€ 185,41</td>
</tr>
<tr>
<td>Simple solver costs</td>
<td>€ 1.440,00</td>
<td>€ 1.521,00</td>
<td>- € 81,00</td>
</tr>
<tr>
<td>Complex solver costs</td>
<td>€ 2.400,00</td>
<td>€ 2.267,50</td>
<td>€ 132,50</td>
</tr>
<tr>
<td>Machinery</td>
<td>€ 1.500,00</td>
<td>€ 1.264,08</td>
<td>€ 235,92</td>
</tr>
</tbody>
</table>

Table 5.9: Summary of resource costs allocation

5.2.3. Conclusion

The application of RCA on the phone repair process of Nauta (2011) has shown that the cost calculations and allocations are not significantly more complex than TDABC and, in fact, even presents a better and compact overview, which makes the RCA more suited to link with a BPMN model. As a consequence, it is concluded that RCA is the better suited accounting technique to determine the direct and indirect financial information of individual activities and resources in a business process and to create a link with a BPMN model.
6. Important financial information for decision-making

The RCA method discloses a lot of (financial) information which should not all be presented in a BPMN model for readability reasons. Therefore, this chapter determines which (financial) information is most important for the decision-making of managers and, as a result, should be shown in a BPMN model. In order to make a justifiable smaller selection of all the available (financial) information in the RCA model, four managers were surveyed by an individual questionnaire. The results from this survey led to a smaller selection of the information in the RCA table which will be used to inform decision-makers in their consult of a BPMN model. First, the structure of the questionnaire is explained in Section 6.1. Subsequently, the results are presented in Section 6.2. Finally, a conclusion is drawn and presented in Section 6.3.

6.1. Structure of the questionnaire

The survey is conducted through the completion of a questionnaire individually. The respondents have moderate knowledge of the BPMN modelling language and, therefore, the researcher was present to support each manager in the completion of the questionnaire. The questionnaire is presented in Appendix V (in Dutch).

The questionnaire consisted of three parts. In the first part, the managers had to indicate how important they think each component of (financial) information from the RCA is in their decision-making. The importance of every component was measured on a 5-point Likert scale, from -2 (not important at all) to +2 (very important). After the results of this part were collected, they are summed up individually in order to determine the important (i.e. sum of more than zero) and the unimportant (i.e. sum of zero and less) components of (financial) information from the RCA. However, the results could indicate that all components of (financial) information from the RCA are important (i.e. the sum of each component is more than zero) and, as already mentioned, not all components can be presented in a BPMN model for readability reasons. Therefore, the second part of the questionnaire forced the respondents to rank the components of (financial) information relative to each other. After the results of this part were collected, every component of (financial) information from the RCA was again summed up individually in order to determine the most important (lowest sum) and the least important (highest sum) component of (financial) information from the RCA. The results of this part enabled the researcher to make an informed choice on which components should be presented in the BPMN model, when the results of part one indicate too much components as important. Finally, the third part of the questionnaire measures the opinion of the respondents on the usage of status symbols in a process model and, when positive, how they should be configured.

Parts one and two divided the components of (financial) information regarding their application on the BPMN elements ‘activity’ or ‘resource’ in the process model. Part one also measured the importance of extra general (financial) information from the RCA which is not particularly applicable on one of the elements raised from Section 4.2 (for instance the total cost of a business process). The results from the first two parts are compared and the most important components of (financial) information for each element of BPMN are determined accordingly.
6.2. Results

This Section describes the results that emerged from the questionnaire. Some demographics about the four respondents are given. The average age of the managers was 48.75 years with a minimum of 46 and a maximum of 51. The gender distribution was 25% women and 75% men.

First, the results are presented regarding the most important (financial) information for the activity element in BPMN. In part one of the questionnaire, all components of (financial) information from the RCA for an activity are rated as important (i.e. sum higher than zero), except for the ‘total time spent on an activity’ with a sum of 0. The ‘total direct costs of an activity’ component is rated as most important with a sum of 8 points, followed up by the ‘time required to execute an activity’ with a sum of 5 points. In part two of the questionnaires, the ‘total direct costs of an activity’ is again rated as most important with a sum of 10 points, and again followed up by the ‘time required to execute an activity’ with a sum of 11 points. An overview of all results is presented in Table 6.1.

<table>
<thead>
<tr>
<th>Component of (financial) information for an activity</th>
<th>Part 1</th>
<th>Part 2</th>
<th>Ranking (low sum = important)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The time required to execute an activity</td>
<td>5</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>The amount that an activity is executed in a period</td>
<td>3</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>The total time spent on an activity</td>
<td>0</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>The total direct costs of an activity</td>
<td>8</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>The total indirect costs of an activity</td>
<td>2</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>The total costs (direct and indirect) of an activity</td>
<td>1</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6.1: Results from the questionnaires on activities

Some observations from these results from both parts can be made. Both parts indicated the ‘total direct costs of an activity’ and ‘time required to execute an activity’ as number one and two in importance. Further, position three in part one is a tie between two components, which are both not indicated as number three in the second part. The ‘total indirect costs of an activity’ is even ranked as number last in part two; while it was ranked as number three in part one.

Secondly, the results are presented regarding the most important (financial) information for the resource element in BPMN. In part one of the questionnaire, the ‘total time that a role or system spends on activities in the process’, the ‘total costs of a role or system in a process’ and the ‘costs per unit of a role or system in a process’ components are indicated as important in part one. Next to that, the ‘total costs of a role or system in a process’ is rated as most important with a sum of 6 points, followed up by the ‘total time that a role or system spends on activities in a process’ with a sum of 5 points. In part two of the questionnaire, the ‘total costs of a role or system in a process’ is again rated as most important with a sum of 6 points, but this time followed up by the ‘costs per unit of a role or system in a process’ with a sum of 11 points. An overview of all results is presented in Table 6.2.
Some observations from these results can be made. Both parts indicated the ‘total direct costs of an activity’ as number one in importance. Secondly, position two in part one (i.e. the ‘total time that a role or system spends on activities in the process’) became position three in part two. The same applies for position three in part one (i.e. the ‘costs per unit of a role or system in a process’), which became position two in part two. Remarkably, the ‘capacity utilization rate of a role or system in a process’ is rated as unimportant (i.e. sum of 0) in part one and as number 4 in part two.

Third, part one also surveyed the respondents on their opinion on more general components of (financial) information which are available in the RCA. From these questions it became clear that all respondents indicated the ‘total costs of a process’, the ‘total income of a process’ and the ‘probabilities for alternatives in a process branch’ as very important with a sum of 7, 4 and 7 respectively. The ‘probabilities for alternatives in a process branch’ component requires an additional calculation step on the available information in RCA.

Fourth, part three surveyed the importance of the usage of status symbols in process models. From this part it became clear that all respondents believe that proper configured status symbols would improve their decision-making. They also think that these status symbols should provide both positive and negative feedback on the process. When they were asked how they would like these status symbols to be configured, several answers were given. Most of the answers can be reduced to the case that a status symbol should indicate when the predicted or approximated is significantly different from reality.

Finally, 75% of the managers responded that they would like the (financial) information presented over the time period of three months. The other 25% preferred the time period of one month.

### 6.3. Conclusion

From the results presented in the previous section, it is concluded that the following (financial) information is important for management decision-making. First, it is concluded that the ‘total direct costs of an activity’ and the ‘time required to execute an activity’ should be presented for each activity in a BPMN model. Secondly, the ‘total costs of a role or system in a process’, the ‘total time that a role or system spends on activities in a process’ and the ‘costs per unit of a role or system in a process’ are the most important components of (financial) information to present for each resource in a BPMN model. Thirdly, the ‘total costs of a process’, the ‘total income of a process’ and the

<table>
<thead>
<tr>
<th>Component of (financial) information for a resource</th>
<th>Part 1</th>
<th>Part 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fixed and variable costs of a business role or system</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>The total time that a role or system spends on activities in the process</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>The total costs of a role or system in a process</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>The available capacity of a role or system</td>
<td>-2</td>
<td>21</td>
</tr>
<tr>
<td>The capacity utilization rate of a role or system in a process</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>The costs for the idle capacity of a role or system in a process</td>
<td>-3</td>
<td>23</td>
</tr>
<tr>
<td>The costs per unit of a role or system in a process</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 6.2: Results from the questionnaires on resources
‘probabilities for alternatives in a process branch’ are important components of (financial) information to present in a BPMN model in general. Fourthly, it is concluded that the usage of status symbols in the process models supports decision-makers in the consult of a BPMN model and will therefore be presented. Those status symbols should be configured in such a way that they can indicate significant differences between the information of systems, models, assumptions and calculations, i.e. a status symbol should indicate when the predicted or approximated is significantly different from the reality. Finally, there is a difference in opinion about what period should be chosen to present the (financial) information. To solve this issue, it is recommended to define the period of time as an input variable in the RCA model which adjusts the output of the whole model accordingly. In this way, the decision-maker is able to configure the presentation of (financial) information over time to his or her own preferences.
7. Approach

Based on Chapters 4 - 6, a stepwise approach is designed that describes how financial information should be determined and included in BPMN models in order to improve the decision-making of managers. The BPMN modelling step is excluded from this approach, because it does not fall within the scope of this research. However, a BPMN model must be available to successfully implement the approach. First, the approach is described in Section 7.1. Second, the implementation result of the approach on an illustrative case is shown in Section 7.2.

7.1. Approach description

Step 1: Determine the financial information of individual activities and resources in a business process

The financial information of all types of activities (i.e. task, send activity, sub-process and multi-instance activity) and some types of resources (i.e. white box pool and swim lane) must be determined. Hence, financial statements, information systems and other more intensive methods (i.e. graphical display of data, statistical analysis techniques, interview, or observations) can be used to obtain this information. In order to allocate the indirect financial information of a business process to individual activities and resources, the Resource Consumption Accounting (RCA) technique from the management accounting discipline must be used. The resources and activities in the RCA model must correspond with the resources and activities in the BPMN model. Eventually, the RCA determines the direct and indirect costs of all individual activities and resources in the business process. After the RCA model is created, it is very important that the RCA is maintained and improved to preserve the accuracy of the analysis and improve the business process.

Step 2: Determine which (financial) information from the RCA model is important for the decision-making of the managers in the business process

After the RCA model is complete, the following (financial) information is available and could be presented in the corresponding BPMN model:

For activities:
- The time required to execute an activity
- The amount that an activity is executed in a period
- The total time spent on an activity
- The total direct costs of an activity
- The total indirect costs of an activity
- The total costs (direct and indirect) of an activity

For resources:
- The fixed and variable costs of a business role or system
- The total time that a role or system spends on activities in the process
- The total costs of a role or system in a process
- The available capacity of a role or system
- The capacity utilization rate of a role or system in a process
- The costs for the idle capacity of a role or system in a process
- The costs per unit of a role or system in a process
For the business process in general:
- The total costs of a process
- The total income of a process
- The probabilities for alternatives in a process branch (this component requires an additional calculation step in the RCA)

From these components of (financial) information it must be determined which information is most important for the decision-making of the managers in the business process. Only the components which are valued as important must be selected for the presentation in the BPMN model. It is recommended that the selection of components should be minimized, in order to improve the readability of the BPMN model. Next to that, positive and negative status symbols could be used in the BPMN model and configured according to the needs of the managers.

As a starting point, the results from the surveyed managers can be used as a guideline. From the results, it was concluded that the following components of (financial) information are important for their decision-making:

For activities:
- The total direct costs of an activity
- The time required to execute an activity

For resources:
- The total costs of a role or system in a process
- The total time that a role or system spends on activities in a process
- The costs per unit of a role or system in a process

For the business process in general:
- The total costs of a process
- The total income of a process
- The probabilities for alternatives in a process branch

It is recommended that those components are shown in the BPMN model. They also stated that the status symbols in the BPMN model should indicate when significant differences exist between information that is predicted (or approximated) and information that is calculated in the RCA model.

Step 3: Extend the presentation of the BPMN model with (financial) information
It is required that the software used for the BPMN modelling of the business process offers the functionality to present and update additional information in the BPMN model. For this study, the software program Microsoft Visio 2013 is used for the BPMN modelling. This software enables the user to add information to the data graphics and link this information with an external data file (for instance an Excel-document). In this way, if changes are made to the data file, Visio updates the data in the BPMN model accordingly. As a result, the user is able to run process simulations. Before software is selected, it is therefore recommended that the presence of these functionalities is ensured in order to use this approach to its full potential.

7.2. Implementation result of the approach on an illustrative case
The result of the application of this approach on the illustrative case of the phone repair process is presented in Figure 7.3. The activity elements now present the total direct costs and the required time for execution. The result for each activity element is shown in Figure 7.1. The status symbols
are configured according to the difference between the cost in the RCA model and the expected costs of an activity. When the result is greater than zero, it is marked with a triangular orange exclamation point; and when the result is less than zero, it is marked with a circular green checkmark.

![Figure 7.1: Activity elements with (financial) information in the phone repair process](image)

The resource elements now present the utilization rate, the total cost, total hours spent on the process, and cost per hour. This information is shown on the right side of each resource’s swim lane (Figure 7.3). For instance, the (financial) information for a simple solver resource is:

- Utilization rate: 106%
- Total cost: € 1,521,00
- Total hours spent: 101,40
- Cost per hour: €15,00

The status symbols of the resources are configured as follows. When the utilization rate of a resource is greater than 100%, a triangular orange exclamation point is shown on the right upper edge of the corresponding swim lane. If the utilization rate of a resource is equal or less than 100%, a circular green checkmark is shown on the right upper edge of the corresponding swim lane. As can be seen in Figure 7.3, only the simple solver has a utilization rate which is greater than 100% and, consequently, only for this resource a triangular orange exclamation point is shown.

Finally, other more general (financial) information is shown for the business process. The Dashboard at the bottom left shows the following financial information:

- The total costs of a process: € 9,507,17
- The total income of a process: € 22,890,00

This means that the profit in the current situation of the phone repair process is € 13,382,83. Next to that, the probabilities for alternatives for each process branch are shown. The probabilities are derived from the total amount of executions from the subsequent activities. For instance, the probability that a phone requires a simple repair or complex repair is 96% and 4% respectively (Figure 7.2).

![Figure 7.2: Probabilities for the type of defect in the phone repair process](image)
Figure 7.3: Phone repair process in BPMN with (financial) information
8. Real case application of the approach

This chapter illustrates the applicability of the approach (Chapter 7) in a real-case. Since none of the earlier studies evaluated the applicability of their conceptual financial extensions to BPMN in practice and, consequently, this is a great gap in the current literature (Chapter 2). The BPMN model of the service product 'DOE-MEE' of the company 'Ploos Energieverlening' is used as the real-case context. First, some general information of Ploos Energieverlening and its service product 'DOE-MEE' is presented in Section 8.1. Secondly, the standard BPMN model of DOE-MEE is presented in Section 8.2. Thirdly, the stepwise implementation of the approach on the BPMN model of DOE-MEE is shown in Section 8.3. Fourth, the extended BPMN model of DOE-MEE with (financial) information is presented in Section 8.4. Finally, the application is discussed in Section 8.5.

8.1. General Information of Ploos Energieverlening

Ploos Energieverlening comprises approximately twenty employees and aims to support customers to regain control over their energy consumption and, as a result, reduce their (unnecessary) energy consumption and related energy costs. This support is mainly created by their internally developed (online) web applications, in which clients have access to their information regarding energy usage, energy cost and potential energy savings. These web applications do not only consider the cost and energy usage as stated by the energy suppliers, but also control and monitor them by recalculating the costs according to the supplied client usage data and location characteristics (i.e. square meter and number of employees). Subsequently, those tools assess the correctness of energy invoices but also expose potential savings by analysing the performance of the different client locations and identify the best and worst. The customers are mainly active in the finance, maintenance and agricultural sectors. In addition, a lot of office, workshop and school locations make use of the services. Ploos Energieverlening offers multiple services which include the activities of: the control of the energy compliance risk, the reduction of CO\textsubscript{2}, the analysis and action on real-time energy consumption data, the procurement of collective energy, the processing and payment of energy invoices, and the determination of energy usage, energy cost and potential savings. It differentiates itself from its competitors (practically world-wide) by providing all these services as one; i.e. by providing the complete energy service portfolio. Ploos Energieverlening acts on a national scale and its organizational structure is given in Appendix VI. Ploos Energieverlening wants to position itself to their (potential) clients as an independent party which enables control and a (guaranteed) reduction of energy consumption and costs by providing professional staff, sound systems, intelligent models, and online feedback.

DOE-MEE service product

DOE-MEE is one of the service products that Ploos Energieverlening offers to customers. It guarantees energy cost savings to a specific customer on a time horizon of one year. DOE-MEE uses the services E&A (Energie & Analyse), CFV (Centrale Factuur Verwerking) and EIM (Energie Inkoop Monitor) and determines the savings realized by these three services to the customer. Ploos Energieverlening takes full responsibility to achieve the projected savings which means the customers will never have to pay additional costs in case the savings are not achieved. Therefore Ploos Energieverlening guarantees the projected savings in all cases and the customers of DOE-MEE will always save money. If Ploos realises fewer savings than projected to the customer, it credits
them proportionately. The CFV service enables Ploos Energieverlening to process the energy invoices of customers centrally. It processes all the energy invoices and advanced payments in its web application and within three business days, it sends the digital information to the customer. Ploos checks whether all the energy bills and advances are received on time, whether they are in line with the anticipated annual budget, and what the consequences are from changes (including climatic changes). The web application checks all the energy invoices and links the energy volumes to building-specific characteristics, such as gross floor area, number of workplaces, number of students, number of animals, litres produced, etc. If the supplier has invoiced too much, Ploos claims back the overpaid amounts. In addition, the E&A service enables Ploos Energieverlening to analyses data from smart meters and telemeters via its web application. Ploos energieverlening sends notifications if it sees saving possibilities by re-adjusting the equipment settings at the customer locations. Further, the EIM service shows the savings of multiple stakeholders on their collective energy procurement.

8.2. **BPMN model of ‘DOE-MEE’**

The BPMN model of ‘DOE-MEE’ had to be modelled before the approach could be implemented. As already mentioned, the BPMN modelling step is not part of the approach. However, the ‘DOE-MEE’ service was yet not described by a BPMN model and, therefore, the DOE-MEE service had to be modelled in BPMN as part of this research in order to allow the evaluation of the approach in a real-case. The software ‘Microsoft Visio 2013’ is used to model the DOE-MEE service process in BPMN. This effort resulted in a BPMN model for DOE-MEE with 12 main processes. All those main processes are described by separate BPMN models. An overview of the usage of the most important BPMN elements in each main business process is presented in Table 8.1. In total, the DOE-MEE BPMN model contains: 78 tasks, 26 send activities, 21 sub-processes, 12 white box pools, 30 swim lanes and 16 black box pools.

<table>
<thead>
<tr>
<th>Main business process</th>
<th># Task</th>
<th># Send activity</th>
<th># Sub-process</th>
<th># White box pool</th>
<th># Swim lane</th>
<th># Black box pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquireren van een nieuwe klant</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Overdracht acquisitie naar lijnorganisatie</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Inregelen basisdata &amp; opstarten abonnementen</td>
<td>14</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Contractverlenging</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Analyse &amp; rapportage</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
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<td>E&amp;A</td>
<td>16</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>CFV</td>
<td>11</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>EIM</td>
<td>3</td>
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<td>0</td>
<td>1</td>
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<td>0</td>
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<tr>
<td>Verwerken Eindafrekening</td>
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<td>2</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Beëindiging DOE-MEE service en contract</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>1</td>
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<td><strong>Total</strong></td>
<td><strong>78</strong></td>
<td><strong>26</strong></td>
<td><strong>21</strong></td>
<td><strong>12</strong></td>
<td><strong>30</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Table 8.1: Overview of the BPMN elements usage in the main processes of DOE-MEE
8.3. Implementation of the approach on a real-case

This section presents the implementation of the approach on the BPMN model of the ‘DOE-MEE’ service product. This section is structured according to the steps in the approach.

Step 1: Determine the direct and indirect financial information of individual activities and resources in a business process

In the first step, the direct and indirect financial information must be determined and the corresponding RCA model must be created. To obtain the required information for the RCA model, all process actors in the BPMN model were asked to complete a form. Those forms were plain text translations of the BPMN model of DOE-MEE and asked each actor: 1.) The average time duration for the execution of a particular activity, 2.) The average total number of executions of a particular activity per month, 3.) what communication tools were used for each send activity in the BPMN model. Obviously, the actors were only asked to provide this information for the activities they perform according to the BPMN process model. For this purpose, fourteen forms were created in line with the fourteen different swim lanes modelled in the BPMN model of DOE-MEE. One other form was used to obtain the general (financial) information from financial statements of the company (i.e. direct labour costs, capacity constraints of employees and other overhead costs of DOE-MEE). Once all the information was obtained, the software ‘Microsoft Excel 2013’ was used to create the data file of the RCA model of DOE-MEE.

Step 2: Determine which (financial) information from the RCA model is important for the decision-making of managers in the business process

In the second step, it must be determined which components of (financial) information from the RCA model of DOE-MEE are important for the decision-making of the DOE-MEE managers and must be shown in the corresponding BPMN model. The surveyed managers in Chapter 6, are all part of the management team of Ploos Energieverlening. This means that the results of Chapter 6 describe which components of (financial) information from the RCA model of DOE-MEE are important for the decision-making of the managers. Consequently, the following components of (financial) information are presented in the BPMN model of DOE-MEE:

For activities:
- The total direct costs of an activity
- The time required to execute an activity

For resources:
- The total costs of a role or system in a process
- The total time that a role or system spends on activities in a process
- The costs per unit of a role or system in a process

For the business process in general:
- The total costs of a process
- The total income of a process

Yet, there was inconsistency about the importance of the ‘capacity utilization rate of a role or system in a process’ component of information. This inconsistency stemmed from the fact that the DOE-MEE service product is relatively new in its existence and covers only a small part of the business activities. Therefore, some managers believed that this information is yet not very helpful.
However, the general manager stressed that it may not be helpful right now, but will be helpful in the future. Therefore, the ‘capacity utilization rate of a role or system in a process’ component is also shown in the BPMN model of DOE-MEE. Next to that, the status symbols in the BPMN model have to indicate when significant differences exist between estimated information and information in the RCA model. Finally, the period of time is defined as an input variable in the RCA model which is able to adjust the information in the entire model accordingly. In this way, the managers of Ploos Energieverlening are able to adjust the time period of the (financial) information. Subsequently, the RCA model had to be modified in Excel accordingly in order to support the presentation of those components of (financial) information in the BPMN model. As a result, the initial RCA model of DOE-MEE had to be extended in order to present the ‘direct costs’ and ‘gateway probabilities’ in the BPMN model.

Step 3: Extend the presentation of the BPMN model with (financial) information
In this step, the actual link between the RCA model (Excel data file) and the BPMN model in Visio had to be established in order to extend the presentation of the BPMN model with (financial) information. For this purpose, the important information from the RCA model were included as external data in Visio. Subsequently, the BPMN elements and its associated (financial) information were linked.

8.4. Extended BPMN model of DOE-MEE
The resulting BPMN model displays the general (financial) process information of DOE-MEE in a dashboard tab and is shown in Figure 8.1. The extended overview of the main processes of DOE-MEE is presented in Figure 8.2. The result of the implementation of the approach on a BPMN model is only shown for the main business process ‘contract renewal’ (in Dutch: contractverlenging) in DOE-MEE (Figure 8.3). The implementation result on all the other main business processes is about the same and is, therefore, not shown.

The triangular orange exclamation point in the Dashboard (Figure 8.1) shows that the account manager business function does not have sufficient work capacity (i.e. the utilization rate is 146,07% which is more than 100%). Further, all required components of (financial) information are shown for each business functions. Despite ‘Systeem Bespaar’, since it represents a system which is currently not restricted by its capacity. Next to that, the dashboard presents that the total costs of the DOE-MEE business process are currently €11.390,08 of which €9.997,81 are direct costs and, as a result, the proportion direct costs is 87,78%. Lastly, the (financial) information is shown for the time period of a month.

The overview of the main processes (Figure 8.2) is divided in the set-up phase (i.e. for new customers), which is the left side of the red dotted line, and the operational phase (i.e. for regular customers), which is the right side of the red dotted line. The triangular orange exclamation points indicate that the current estimations of the total costs of some main processes are less than the cost calculated by the RCA model. Next to that, the main process that describes the start-up to acquire energy consumption data of a customer and start the subscription has the highest total cost (€6.733,80) which is 59,12% of the total costs of DOE-MEE. Finally, the BPMN model of the contract renewal main business process (Figure 8.3) shows the required (financial) information for each activity and the probabilities for each alternative after a process branch.
Figure 8.1: Dashboard of the extended BPMN model of DOE-MEE

Figure 8.2: Overview of the main processes of the extended BPMN model of DOE-MEE
Figure 8.3: The main process 'contractverlenging' in the extended BPMN model of DOE-MEE
8.5. Discussion of the approach implementation in a real-case

The previous sections illustrated the implementation of the approach in a real-case. This section presents a discussion on the application.

Since the DOE-MEE service is relatively new in its existence, the information systems of Ploos Energieverlening did not have the required (financial) information of the DOE-MEE service process available. Therefore, the use of the more intensive information retrieval method was inevitable, i.e. each process actor had to complete a form. The use of this method was very time consuming and led to subjective data (that could significantly differ from reality). Ploos Energieverlening has yet expressed its intention to automate the information retrieval in the models as much as possible, and as soon as possible.

Some recommendations are given based on issues that were encountered during the application of the approach on the BPMN model of DOE-MEE.

First, the initial BPMN model of DOE-MEE used intermediate and throw message events to represent communications from the process with external parties. As concluded in Section 4.2, events are instantaneous which means that they do not have time durations associated. However, communication requires time, in general. For instance, an email has to be prepared before being sent, and the preparation requires time from an employee. Next to that, the communication may also take place by means of a telephone conversation or a physical conversation which, again, both require time of an employee. In addition, communication can result in postage, telephone and travel costs. Therefore, instead of using of intermediate and throw message events, send activities should be used. Since send activities are able to represent the time and cost of communications.

Second, gateways also do not retain tokens and, therefore, have no time consumption. However, they often require a manual interference by employees, like a decision which requires time in general. In order to show the costs in the BPMN model appropriately, a task must be placed before each gateway that requires a manual interference. In this way, the task is able to present the time and cost of this manual interference.

Third, when gateways are passed, each alternative path must be linked with an activity. In this way, the activity is able to present the time and cost for each alternative branch. For example, when rework is required, in general, additional costs are associated; and the direct connection of the gateway to an earlier gateway in the process would not be appropriate, while the additional time and costs of the rework cannot be assigned to a BPMN element.

Finally, it is advised to separate activities when a part of the activity consumes proportionally significantly more time or cost. This will lead to a better accurate presentation of the (financial) information in the BPMN model.

After those recommendations were processed, the BPMN model of DOE-MEE was able to present all required (financial) information (Figures 8.1-8.3). From this result, it can be concluded that eventually all steps from the approach were successfully performed on a real-case. Consequently, the applicability of the approach in practice is successfully illustrated.
9. Conclusion

In this final chapter, the following is provided. First, the research goal and questions are discussed in Section 9.1. Second, recommendations are presented for the design of a BPMN model in Section 9.2. Third, the benefits from the application of the approach are presented in Section 9.3. Fourth, the limitations are presented in Section 9.4. Finally, in Section 9.5 the directions for further research are presented.

9.1. Discussion of research goal and questions

This study aimed to design an approach, which describes a stepwise how financial information must be determined and included in the BPMN modelling language, with the ultimate aim to improve the decision-making of process managers. To that end, an integration of concepts from the Business Process Management and management accounting discipline was required. More specifically, the BPMN modelling language was extended with financial information from the RCA accounting method. To evaluate the overall result of this study, the degree of satisfaction is considered on the answers to the research questions, and subsequently, to the main research question of Section 3.3. The following research questions were defined and are answered below:

**Research question 1: What operational financial process information exists?**

Financial information is caused directly or indirectly by elements in a business process model. Direct and indirect financial information can be further subdivided in variable or fixed types of financial information; while indirect financial information can only be classified as overhead. It is observed that the factor of time and the capacity of resources or activities are important properties for both variable and fixed types of financial information. This means that variable and fixed types of financial information are dependent on the resource usage and consumption of a company (i.e. the use of employees, machines, systems, office supplies, communication tools, raw materials, etc.). In addition, overhead is caused by supportive business functions (like administration, marketing, sales, and IT) which are not directly involved in the business process, but are essential for the existence of a business as a whole. Therefore, it is important that overhead is also considered for the adequate assessment of the total costs incurred by a business process. In short, direct and indirect financial information, which can be variable, fixed or overhead, exist in a business process.

**Research question 2: Which BPMN elements are suited to present financial information in a business process model?**

The properties of financial information (research question 1) were analysed and it was concluded that the following properties are important drivers for financial information: the amount of time (i.e. durations), the type of resource, the capacity of a resource, the number of task executions and the number of output units. Subsequently, BPMN elements were explored on similarities or compatibilities with those important drivers for financial information. As a result, it was concluded that the properties of events, gateways, data elements, connecting objects and black box pools are not compatible with the important drivers of financial information and, therefore, are not suited to present financial information in a business process model. Consequently, it was concluded that the properties of the following BPMN elements are compatible with the important drivers of financial
information and, therefore, are suited to determine and represent financial information in a BPMN model: task, send activity, sub-process, multi-instance activity and swim lane (in a white box pool).

### Research question 3: What is the best way to determine the financial information of individual elements in a BPMN model?

A company can use financial statements, information systems, and more intensive data gathering methods (i.e. graphical data display, statistical techniques, interviews, and observations) to determine the direct and indirect financial information of the business process. However, those methods fail to allocate indirect financial information to individual elements in the business process. The Management Accounting technique designed three techniques to resolve this issue: Activity-Based Costing (ABC), Time-Driven ABC (TDABC), and Resource Consumption Accounting (RCA). The accounting techniques are built on the premise that a common but distinct property must be observed and measured among the considered elements, which provides a reasonable basis to assign indirect financial information to one element or another. Therefore, it defines a cost driver for each resource (overhead is also considered as a resource) and assigns financial information to activities according to their resource consumption. This means that indirect resource costs are only allocated to an activity when it actually consumes the resource. Based on literature, it turned out that the ABC accounting technique has a lot of severe limitations. The TDABC and RCA accounting techniques were developed in order to resolve those limitations (Szychta, 2010; Tse & Gong, 2009). For instance, they simplified the cost analysis by changing from a collective to an individual cost analysis. In this way, cost models can be updated more easily by adding or removing cost pools and activities without disrupting other cost objects in the model (Tse & Gong, 2009). However, the TDABC and RCA accounting techniques also differ in some important aspects. However, based on those differences, no strong conclusion could yet be drawn on whether the TDABC or the RCA technique is best suited to have a link with a BPMN model. Therefore, both techniques were applied on the illustrative case of the telephone repair process. The application of RCA on the phone repair process of Nauta (2011) has shown that the cost calculations and allocations are not significantly more complex than TDABC and, in fact, even presents a better and compact overview, which makes the RCA more suited to link with a BPMN model. As a consequence, it is concluded that RCA is the better suited accounting technique to determine the direct and indirect financial information of individual activities and resources in a business process and to create a link with a BPMN model. Even more since the accounting techniques also benefits from the use of BPM models. BPM models identify all individual activities that take place in a system, from the beginning to the end, in a more accurate way than the methods used in the management accounting discipline (Hadzilias, 2005). Next to that, BPM models greatly help to reduce time used for modelling and overcome the difficulties present in creating the cost models in Management Accounting. In short, the RCA accounting technique is able to adequately allocate direct and indirect financial information to individual activities and resources in a BPMN model.
Research question 4: What financial information is important for management decision-making in a business process model?

The RCA model contains a lot of (financial) information which should not all be presented in a BPMN model for readability reasons. A justifiable smaller selection of all the available (financial) information in the RCA model is determined by a questionnaire. This questionnaire was completed by four managers individually and measured which financial information is important for their management decision-making. The respondents had moderate knowledge of the BPMN modelling language and, therefore, the researcher was present to support each manager in the completion of the questionnaire. The used questionnaire is presented in Appendix V (in Dutch). From the results of the completed questionnaires, it was concluded that for the activity BPMN element the ‘total direct costs of an activity’ and the ‘time required to execute an activity’ are the most important components of (financial) information for decision-making and, as a result, those components should be presented for each activity element in a BPMN model. In addition, it was found that for the resource BPMN element the ‘total costs of a role or system in a process’, the ‘total time that a role or system spends on activities in a process’, and the ‘costs per unit of a role or system in a process’ are the most important components of (financial) information for decision-making and, as a result, those components should be presented for each resource element in a BPMN model. Next to that, the ‘total costs of a process’, the ‘total income of a process’, and the ‘probabilities for alternatives in a process branch’ are important general components of (financial) information for decision-making and should be presented in each BPMN model. Finally, it was concluded that positive and negative status symbols improve the decision-making of managers in the consultation of a BPMN model and should be presented. They should be configured in such a way that they are able to indicate significant differences between predicted (or approximated) information and information in the RCA model. However, the approach allows users to select other (financial) information from the RCA model and present it in the BPMN model accordingly.

Main research question: “How can the presentation of BPMN models be extended with financial information in order to improve management decision-making?”

Based on the answers to the research questions above, it can be concluded that the research succeeded to answer the main research question by designing an approach which clearly describes how financial information should be determined and included in BPMN models in order to improve the decision-making of managers. The applicability of the approach is also validated, since it was successfully applied on a real-case.

9.2. Design recommendations

Some recommendations can be given for the design of a BPMN model in order to support financial information to its full potential:

Uses send activities, instead of throw message events

Since a send activity has the property to consume time and an (throw message) event does not, it is recommended to use send activities instead of throw message events in the BPMN model in order to present financial information accordingly.
Place an activity before each gateway that requires a manual intervention
In order to show the costs in the BPMN model appropriately, a task must be placed before each gateway that requires a manual interference. In this way, the task is able to present the time and cost of this manual interference.

Represent each alternative path of a gateway with at least one activity
Each alternative outgoing path of a gateway must be linked with an activity. In this way, the activity is able to present the time and cost for each alternative branch.

Present an activity separately when it consumes a significant amount of time or cost
It is advised to separate activities when a part of the activity consumes proportionally significantly more time or cost. This will lead to a better accurate presentation of the (financial) information in the BPMN model.

Create a link between the RCA model and an information system
The models should be maintained to prevent them to become obsolete and useless after some time. The use of the more intensive data gathering methods (i.e. graphical data display, statistical techniques, interviews, and observations) is not recommended to maintain the RCA model, since those methods are very time consuming and lead to subjective data (that could significantly differ from reality). Consequently, it is advised to use a link with an information system to maintain the RCA model in order to save time and obtain accurate information.

9.3. Benefits from the application of the approach
Through the implementation of the approach and the use of the resulting models, important financial information for decision-making becomes available in a manner that provides a better overview than existing techniques. Consequently, the resulting models offer great benefits to the decision-making of managers and, subsequently, to the overall business operations of a company.

First, the models lead to a clearer, undistorted and accurate overview of the causes of direct and indirect (i.e. overhead) financial information for each activity and resource in a business process. In this way, it generates knowledge which helps managers to identify inefficient processes or bottlenecks and, consequently, initiate improvement efforts. For instance, those efforts could aim to optimize the resource capacity and relieve bottlenecks in the business process which are expected to persist in future periods, or reduce the capacity in departments where any unused capacity is expected to persist for several periods into the future. Next to that, a manager could decide to remove or add activities or increase the price of a product or service in order to improve efficiency and reduce or cover the business costs. Hence, those models generate relevant information for both the long- and short-term in strategic business management. Finally, the possibilities shown for each outgoing path of a gateway can help a manager to identify high costs which are caused by a process path that is executed too often (for instance, an exception of the process is executed too often). Subsequently, the manager could take action to decrease the undesired number of executions of the considered process path and save costs.

Second, the model is compatible with fixed, variable and overhead types of financial information and allows for the concurrent use of multiple drivers to describe the consumption of resources. The compatibility with variable financial information, in particular, means that the approach succeeded
to create a model that adheres to a temporal perspective, while the lack of a temporal perspective was a common limitation among the earlier studies on the incorporation of financial information in BPMN.

Third, the link between the BPMN modelling program (Microsoft Visio 2013) and the RCA model (Microsoft Excel 2013) allows the user to change input variables and generate the corresponding result instantly. In this way, managers are able to evaluate multiple outcomes according to their applied changes on the input variables, i.e. the approach is able to serve the purpose of process simulation and analysis.

9.4. Limitations
The contribution of this research should be viewed in light of some limitations.

First, the results from Chapter 6 are based on the opinion of only four managers. Next to that, those managers are employed at the same company. This means that the answers could be very specific to the business operations and work area of their business, i.e. a small service company in the energy sector. One example to illustrate the difference in opinions among managers is already observed for this small group of respondents of the same company. While one component of (financial) information was valued as less important by some managers, since the considered service was relatively new in its existence and covered only a small part of the business activities. Consequently, the majority of the managers concluded that it would be meaningless for their decision-making in the short-term. However, the General Manager stressed that this information will become very important in the future of the service and, therefore, the component was added to the BPMN model of DOE-MEE.

Second, when some significant alterations have to be made to the model, they have to be done manually in the current approach setup. For instance, when a new task has to be added, it must first be added in the BPMN model and, second, it must also be added to several tables in the RCA model. Then again, the information from the data file must be loaded into Visio and linked to the corresponding BPMN task. For resource elements, this procedure is about the same. Therefore, it is advised to maintain and update the models only after some time if multiple alterations are required. In this way, the user can alter multiple elements of the models at once which will save time.

Third, if the information in the models is not automatically maintained and updated by an information system, the models will probably become obsolete and inaccurate in a matter of time. Since a manual maintenance of the models requires a considerable effort and this effort will probably constitute a big barrier to the sufficient maintenance of the models. Insufficient maintenance will eventually lead to non-use of the models as an analysis method in a company.

9.5. Directions for Future Research
Some directions for future work are interesting and are presented.

First, future work could focus on the further automation of the maintenance of the models that result from the approach. More automation is desired, while the maintenance of the models still requires significant effort and time which can possibly cause the discontinuance of the models in a
company. Hence, the effort and required time to maintain the models could be greatly reduced by more automation through a stronger link between the models and information systems.

Second, the models used in the current study only considered the duration of tasks and the time required for rework (by the use of process loops). However, one could also think of other types of time, like transfer time, queue time, wait time, set up time, inspection time, and downtime. Those times were not considered in the current research.

Third, while the results from Chapter 6 are based on the opinion of only four managers, the research on the importance of the components of (financial) information from the RCA could be repeated with more managers from different companies. It would be interesting, for instance, to observe if there are components that are valued as important by the majority of the managers, or only by a particular business sector, or even by specific business context. This research could also lead to new insights on the use and configuration of status symbols in business process models.

Fourth, the BPMN modelling language has the most potential, is currently the most widely used modelling language for capturing business processes by companies, and is still rising in its popularity. However, it would still be interesting to research if the approach is also applicable on other modelling languages. Modelling languages have a lot of similarities and, therefore, it is expected that it should not be too hard to modify the approach and apply it on other modelling languages. For instance, Petri nets contain places, transitions, and arcs. A place retains tokens and will therefore probably have costs associated which can be presented in a Petri net model. A transition ‘fires’ instantaneously and, therefore, does not consume time. However, if a place has multiple subsequent transitions, there could be different costs associated with the ‘firing’ of those transitions and the process could be configured in such a way that it chooses the cheapest transition to fire.

Fifth, it could be interesting to research the functionalities and possibilities of other software programs in combination with the approach. The choice to use the software program ‘Microsoft Visio 2013’ in combination with ‘Microsoft Excel 2013’ is solely based on the fact that Ploos Energieverlening has only access to this BPMN modelling software and they will continue to use the DOE-MEE models after the completion of this research. It was undesired to use or buy additional software with (uncertain) additional functionalities in the research area.
10. Bibliography


## Appendix I: Overview of Research Frameworks and Concepts of Chapter 2

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Petri Net model cost extension (Thabet, Ghannouchi and Ghézala, 2014)</td>
<td>1. The extraction of cost information from cost annotated event logs 2. The memory loading of the Petri Net model 3. The computation of cost information of the elements of the Petri Net.</td>
<td>- an average, maximum or minimum amount of the cost of a process (instance) can be determined - extension enriches the business process model with a wealth of information about the operational level</td>
<td>- not tested empirically</td>
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<tr>
<td>process accounting model (PAM) (Sonnenberg and Vom Brocke, 2014)</td>
<td>The PAM is capable to integrate and structure accounting data and process data in support of the design of business processes.</td>
<td>- economic consistency, while it accounts for economic reciprocity</td>
<td>- The current PAM is yet not user-friendly to both process managers and accountants. It does not support the identification and classification of relevant business events and economic events. This issue relates to process modelling support and the re-use of process models for accounting purposes. In particular, current process modelling formalisms should be augmented with constructs that enable process designers, accountants, and auditors to describe the economic interdependencies among processes.</td>
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<tr>
<td>priced resource-constrained workflow Nets (prcwf-Nets) (Martos-Salgado and Rosa-Velardo, 2012)</td>
<td>Extend the research on workflow nets with discrete prices concerning transition firing and place storage.</td>
<td>- added firing and storage costs to wf-nets and rcwf-nets - the prcwf-Nets define priority or preference rules to prevent non-determinism and unnecessary costs</td>
<td>- the model does not account for the variable time in the context of storage costs calculations - not tested empirically</td>
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<td>ABC integrated in subject-oriented Business Process Management (S-BPM) (Zehbold, Schmidt and Fleischmann, 2013)</td>
<td>Integrates the ABC technique into the subject-oriented Business Process Management (S-BPM) modelling language. In line with the ABC technique they use the concept of a cost driver. However, instead of determining different cost drivers they assign one major cost driver and allocate all other cost types proportionally in order to keep things simple. The next step would be to assign the subjects to the elements of the current organizational structure. In combination with the duration data retrieved from event logs the total process duration can be determined and used to calculate the total process cost.</td>
<td>- its characteristic to keep things simple and easy to use in practice on many different processes</td>
<td>- its particular application on people intensive areas with a high degree of indirect costs (like services) - not tested empirically sufficiently</td>
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<tr>
<td>Method</td>
<td>Action</td>
<td>Advantages</td>
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<td>Event-driven Process Chain (EPC) modelling language (Vom Brocke, Mendling and Recker, 2010)</td>
<td>The framework identifies and assesses several consumption and usage factors as operational input in the business process. The framework can calculate different payments of a process (instance) fully or partitioned, according to different functions, schemas and keys. After those process (instance) payments are determined, they have to be aggregated for each specific process and each period within the planning-horizon. Ultimately, this approach determines all relevant payments and receivables apparent in the process instances of the EPC model.</td>
<td>- The framework is a process modelling practice that not only takes into account the mere behavioural aspects of business operations but also puts the design into perspective – in our case into the perspective of long-term financial consequences.</td>
<td>- is about value considerations in the process change initiative instead of value considerations in a new process design - not tested empirically sufficiently</td>
</tr>
<tr>
<td>BPMN extension (Magnani and Montesi, 2007)</td>
<td>An extension to enable BPMN to include cost considerations in the business process models. Their proposed extensions include specifying the cost of each element as a property, specifying cost intervals for each element and specifying average cost for each element.</td>
<td>- it defines classes of diagrams for which the management of costs can be reduced to existing and well-studied problems</td>
<td>- does not account for process branches - A lot of BPMN constructs have not been taken account for - the variable of time is yet missing in the extension - empirical testing is lacking</td>
</tr>
<tr>
<td>BPMN extension (Sampath and Wirsing, 2009)</td>
<td>This extensions elaborates on the research of Magnani and Montesi (2007) by adding the concept of reliability to the cost calculation of each task or activity.</td>
<td>- the ‘Business Cost of the Process’ can be determined in a more reliable and accurate manner - the method calculates the cost, Business Cost and reliability of a Business Process while it considers the reliability of each of the artefacts</td>
<td>- does not account for process branches - A lot of BPMN constructs have not been taken account for - the variable of time is yet missing in the extension - empirical testing is lacking</td>
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<tr>
<td>BPMN-Finance notation (Mueller-Wickop, Schultz, Gehrke and Nüttgens, 2011)</td>
<td>BPMN-Finance notation addresses the lack of financial value-flows in traditional modelling languages. As a result, they provide a visualization form which uses colours to identify financial types and is supported by process mining.</td>
<td>- BPMN-Finance notation helps managers to shift to a more process-oriented-view, while it exposes the processes responsible for the financial entries in the organization. - it will also result in a better and faster understanding of the interdependencies and procedures within the accounting function by allowing an easier cognitive processing</td>
<td>- Variable costs are not accounted for - the focus is on graphical display (no computations are shown)</td>
</tr>
</tbody>
</table>
## Appendix II: An overview of the most important constructs in the BPMN modelling language and their corresponding properties

<table>
<thead>
<tr>
<th>BPMN Construct</th>
<th>Represents</th>
<th>Important</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Events</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start event</td>
<td>Indicates when instances of the process start</td>
<td>Events are instantaneous, since they cannot retain tokens as opposed to activities which retain tokens for the duration of their execution</td>
</tr>
<tr>
<td>End event</td>
<td>Indicates when instances complete</td>
<td></td>
</tr>
<tr>
<td>Message (external) event</td>
<td>When a message flow is incident to an event.</td>
<td>It can be linked to an output data object in order to store the content of the incoming message.</td>
</tr>
<tr>
<td>Timer (external) event</td>
<td>Indicates that process instances start upon the occurrence of a specific temporal event, or to model a temporal interval that needs to elapse before the process instance can proceed.</td>
<td></td>
</tr>
<tr>
<td>Exception (or error) event</td>
<td>Events that deviate from its normal course, i.e. from what us commonly known as the “sunny-day” scenario.</td>
<td></td>
</tr>
<tr>
<td><strong>Activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>An activity capturing a unit of work that cannot be further broken down</td>
<td>Activities consume time. They retain tokens for the duration of their execution.</td>
</tr>
<tr>
<td>Send activity</td>
<td>An activity that is the source of a message</td>
<td></td>
</tr>
<tr>
<td>Sub-process</td>
<td>A self-contained, composite activity that can be broken down into smaller units of work</td>
<td>A sub-process identifies groups of related activities, i.e. those activities which together achieve a particular goal or generate a particular outcome. A start and end event should be added to a sub-process, to explicitly indicate when the sub-process starts and completes.</td>
</tr>
<tr>
<td>Multi-instance activity</td>
<td>An activity (being it a task or a sub-process) that is executed multiple times concurrently (for multiple entities or data items).</td>
<td></td>
</tr>
<tr>
<td><strong>Gateways</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Split gateway</td>
<td>A point where the process flow diverges. Generally, splits have one incoming sequence flow and multiple outgoing sequence flows.</td>
<td></td>
</tr>
<tr>
<td>Join gateway</td>
<td>A point where the process flow converges. Generally, joins have multiple incoming sequence flow and one outgoing sequence flow.</td>
<td></td>
</tr>
<tr>
<td>Exclusive decision /data XOR-split</td>
<td>When two or more activities are alternative to each other, i.e. only one outgoing branch can be taken</td>
<td>Make sure each outgoing flow is annotated with a label capturing the condition upon which that specific branch is taken, i.e. always use mutually exclusive conditions.</td>
</tr>
<tr>
<td>XOR-join</td>
<td>The merge of two or more alternative branches that may have previously been forked with an XOR-split, i.e. an XOR-join aligns the process whenever an incoming branch is completed.</td>
<td></td>
</tr>
<tr>
<td>Parallel AND-split</td>
<td>When two or more activities can be performed at the same time, because they are not interdependent. In other words, one activity does not need to follow the other, nor it excludes the other. It models the parallel execution of two or more branches.</td>
<td></td>
</tr>
<tr>
<td>AND-join</td>
<td>It synchronizes the execution of two or more parallel branches</td>
<td></td>
</tr>
<tr>
<td>Inclusive (OR-split) decision</td>
<td>When one or more conditions of outgoing branches are true and can be taken after a decision activity, i.e. the outgoing branches are</td>
<td>May confuse the reader. Thus, use it only when it is strictly required.</td>
</tr>
</tbody>
</table>
### OR-join
It waits for all incoming active branches to complete and, subsequently, merges (in the case of more than one active branches) or passes (in the case of one active branch) them.

### Event-based exclusive (XOR) split
It determines the continuation of the process according to the first external event to occur. Its input solely consists of external events, meaning that the process environment determines the outcome of the process gateway. The branches emanating from an event-based split are merged with a normal XOR-join. It is very convenient to use it as the counterpart of an internal decision on a collaborating party.

### Data elements
- **Data object**: Information flowing in and out of activities. It is not important in which lanes data objects are put. State of data object: When an activity is dependent on the state of a data object (e.g., confirmed or completed purchase order).
- **Data store**: Place containing data objects that need to be persisted beyond the duration of the process instance.

### Resources
- **Pool**: Resource class/Participant: Not explicit referral to one resource at a time, but instead a referral to a group of resources that are interchangeable in the sense that any member of the group can perform a given activity. BPMN only considers active resources (i.e., resources that can autonomously perform an activity, like an employee and not like a printer). Sequence flows cannot be used to connect activities that belong to different pools since the sequence flow cannot cross the boundary of the pool. For this, message flows are used.
- **Multi-instance pool**: A set of resource classes, or resources, having similar characteristics.
- **Swim lane**: Partition of a pool into subclasses or single resources. Lanes can be nested within each other in multiple levels. Obviously, it is of essence that the right activities and events are placed within the right lane. Bear in mind, that in BPMN each activity can be performed by one resource only. If an activity is performed by an intersection of resources, a lane has to be created which represents all properties of both resources. Participants should not be captured by their names since individuals tend to change frequently within an organization. Participant’s roles should be used instead. On the other hand, specific software systems or equipment may be named, since these changes less frequently within an organization.
- **Private process or white box pool**: Shows the activities, events, gateways and data objects of the participating organization. A message flow, unlike a sequence flow, may cross the boundary of a white box pool and connect directly with an activity in another white box pool or connect with the boundary of another black box pool.
- **Public process or black box pool**: Does not show the activities, events, gateways and data objects of the participating organization. A message flow, unlike a sequence flow, may emanate from the boundary of a black box pool and connect with the boundary of another black box pool or connect directly with an activity in another white box pool.

### Connecting objects
- **Sequence flow**: Describe the sequential relationship between instances of the process model.
- **Association (one- or bidirectional)**: Links a data object or database to an activity. Data elements and their associations with activities cannot replace the sequence flow.
- **Message flow**: The flow of information between two separate resource classes (Pools), i.e., it models any type of communication between two separate organizations. It has to bear a label indicating the content of the message. A message flow may lead to the creation of a data object by the activity that receives the message.
Appendix III: Phone repair process in BPMN
Appendix IV: TDABC allocation tables of the remaining resources

**Allocation of simple solver costs to activities:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Resource-activity driver</th>
<th>Unit of activity</th>
<th>Cost allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple repair</td>
<td>0.3</td>
<td>€ 5</td>
<td>338</td>
<td>€ 1,521,00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>€ 1,521,00</strong></td>
</tr>
</tbody>
</table>

**Allocation of complex solver costs to activities:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Resource-activity driver</th>
<th>Unit of activity</th>
<th>Cost allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine issue</td>
<td>0.05</td>
<td>€ 1.25</td>
<td>95</td>
<td>€ 118,75</td>
</tr>
<tr>
<td>Repair screen</td>
<td>0.90</td>
<td>€ 22.50</td>
<td>52</td>
<td>€ 1,170.00</td>
</tr>
<tr>
<td>Repair case</td>
<td>0.60</td>
<td>€ 15.00</td>
<td>42</td>
<td>€ 630.00</td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td>0.45</td>
<td>€ 11.25</td>
<td>31</td>
<td>€ 348.75</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>€ 2,267.50</strong></td>
</tr>
</tbody>
</table>

**Allocation of depreciation costs to activities:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Resource activity driver</th>
<th>Unit of activity</th>
<th>Cost allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>0.03</td>
<td>€ 0.15</td>
<td>370</td>
<td>€ 57.23</td>
</tr>
<tr>
<td>Inform customer</td>
<td>0.02</td>
<td>€ 0.08</td>
<td>370</td>
<td>€ 29.48</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>0.30</td>
<td>€ 1.41</td>
<td>370</td>
<td>€ 520.31</td>
</tr>
<tr>
<td>Simple repair</td>
<td>0.30</td>
<td>€ 1.41</td>
<td>338</td>
<td>€ 475.31</td>
</tr>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine issue</td>
<td>0.05</td>
<td>€ 0.23</td>
<td>95</td>
<td>€ 22.27</td>
</tr>
<tr>
<td>Repair screen</td>
<td>0.90</td>
<td>€ 4.22</td>
<td>52</td>
<td>€ 219.38</td>
</tr>
<tr>
<td>Repair case</td>
<td>0.60</td>
<td>€ 2.81</td>
<td>42</td>
<td>€ 118.13</td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td>0.45</td>
<td>€ 2.11</td>
<td>31</td>
<td>€ 65.39</td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>0.05</td>
<td>€ 0.23</td>
<td>401</td>
<td>€ 93.98</td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>0.02</td>
<td>€ 0.08</td>
<td>31</td>
<td>€ 2.47</td>
</tr>
<tr>
<td>Restart repair</td>
<td>0.05</td>
<td>€ 2.34</td>
<td>31</td>
<td>€ 72.66</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>0.02</td>
<td>€ 0.09</td>
<td>372</td>
<td>€ 30.66</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>0.10</td>
<td>€ 0.47</td>
<td>42</td>
<td>€ 19.69</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>0.04</td>
<td>€ 0.19</td>
<td>370</td>
<td>€ 69.38</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>€ 1,796.33</strong></td>
</tr>
</tbody>
</table>
### Allocation of energy costs to activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time per unit (hours)</th>
<th>Resource activity driver</th>
<th>Unit of activity</th>
<th>Cost allocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register phone</td>
<td>0,03</td>
<td>€ 0,20</td>
<td>370</td>
<td>€ 74,07</td>
</tr>
<tr>
<td>Inform customer</td>
<td>0,02</td>
<td>€ 0,10</td>
<td>370</td>
<td>€ 38,16</td>
</tr>
<tr>
<td>Analyse defect</td>
<td>0,30</td>
<td>€ 1,82</td>
<td>370</td>
<td>€ 673,33</td>
</tr>
<tr>
<td>Simple repair</td>
<td>0,30</td>
<td>€ 1,82</td>
<td>338</td>
<td>€ 615,10</td>
</tr>
<tr>
<td>Complex repair</td>
<td></td>
<td></td>
<td></td>
<td>€ 550,19</td>
</tr>
<tr>
<td>Determine issue</td>
<td>0,05</td>
<td>€ 0,30</td>
<td>95</td>
<td>€ 28,81</td>
</tr>
<tr>
<td>Repair screen</td>
<td>0,90</td>
<td>€ 5,46</td>
<td>52</td>
<td>€ 283,89</td>
</tr>
<tr>
<td>Repair case</td>
<td>0,60</td>
<td>€ 3,64</td>
<td>42</td>
<td>€ 152,87</td>
</tr>
<tr>
<td>Repair stuck or loose button(s)</td>
<td>0,45</td>
<td>€ 2,73</td>
<td>31</td>
<td>€ 84,62</td>
</tr>
<tr>
<td>Test repaired phone</td>
<td>0,05</td>
<td>€ 0,30</td>
<td>401</td>
<td>€ 121,62</td>
</tr>
<tr>
<td>Request action to be performed</td>
<td>0,02</td>
<td>€ 0,10</td>
<td>31</td>
<td>€ 9,40</td>
</tr>
<tr>
<td>Restart repair</td>
<td>0,05</td>
<td>€ 0,30</td>
<td>31</td>
<td>€ 9,40</td>
</tr>
<tr>
<td>Archive fixed phone result</td>
<td>0,02</td>
<td>€ 0,12</td>
<td>372</td>
<td>€ 39,67</td>
</tr>
<tr>
<td>Archive not fixed phone result</td>
<td>0,10</td>
<td>€ 0,61</td>
<td>42</td>
<td>€ 25,48</td>
</tr>
<tr>
<td>Send phone to customer</td>
<td>0,04</td>
<td>€ 0,24</td>
<td>370</td>
<td>€ 89,78</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>€ 2,240,00</strong></td>
</tr>
</tbody>
</table>
Appendix V: Questionnaire Management Team Ploos Energieverlening

Vragenlijst MT

Welke (financiële) informatie uit de RCA tabel is geschikt voor de weergave in het procesmodel om de besluitvorming te bevorderen?

Educatieve achtergrond: .................................................................

Leeftijd: ........................................................................

Geslacht: Man Vrouw

☐ ☐
**Toelichting vragenlijst**

De volgende vragenlijst bevat iedere component aan (financiële) informatie uit de RCA tabel van DOE-MEE. De RCA methode biedt verschillende informatie mogelijkheden om de besluitvorming van managers te ondersteunen. Ten eerste, biedt RCA de mogelijkheid om de kosten van individuele activiteiten te bepalen aan de hand van het gebruik van werknemers of machines (directe kosten) of aan de hand van ondersteunende middelen die indirect aan het proces gekoppeld zijn (zoals de IT en de helpdesk afdeling, maar ook het gebruik van het kantoorpand). De som van de directe en indirecte kosten voor iedere individuele activiteit in een proces kan zorgen voor verschillende inzichten. Een inzicht kan zijn dat een activiteit (of een groep activiteiten) hoge kosten veroorzaakt, terwijl die kosten te vermijden zijn door bijvoorbeeld automatisering. Een ander inzicht kan zijn dat een bepaald onwenselijk pad binnen het proces (te) vaak genomen wordt met hoge kosten tot gevolg. In dit geval kan gekeken worden of er eerder in het proces maatregele kunnen worden genomen om de kans voor dit onwenselijk pad te verkleinen en daarmee de kosten te verlagen. Ten tweede biedt RCA de mogelijkheid om de middelen (zoals werknemers, machines of systemen) die gebruikt worden in een proces te evalueren. Uit de analyse van RCA kan dan blijken dat bepaalde werknemers of machines niet optimaal benut worden en dus hoge kosten kennen voor de onbenutte capaciteit. Deze informatie kan de basis voor een besluit vormen om werknemers of machines anders in te zetten.

Deze vragenlijst heeft als doel om inzicht te krijgen in welke informatie uit de RCA tabel u (als lid van het MT) het belangrijkst vindt met betrekking tot het maken van beslissingen. Vervolgens zal het resultaat van deze vragenlijst worden gebruikt om de corresponderende (financiële) informatie in het BPMN model van DOE-MEE weer te geven. Hieronder ziet u een voorbeeld van hoe de BPMN elementen eruit kunnen zien met (financiële) informatie.

**Taak:**

![Standaard](image1)

![Met (financiële) informatie](image2)

**Middel:**

![Standaard](image3)

![Met (financiële) informatie](image4)
Zoals u kunt zien, zijn beide BPMN elementen in zowel hun standaard als uitgebreide vorm weergegeven. De uitgebreide vorm is uitsluitend bedoeld als illustratie van de presentatie mogelijkheden met betrekking tot de (financiële) informatie (tekst: €1.500,00, gegevensbalk: 110% en pictogram: driehoekig oranje uitroepteken). Bij beide elementen kan er dus nog informatie worden toegevoegd, verwijderd of veranderd.

De vragenlijst bestaat uit drie onderdelen. Het eerste onderdeel onderzoekt hoe belangrijkheid u ieder component uit de RCA tabel vindt voor uw besluitvorming. Het tweede onderdeel onderzoekt de relatieve belangrijkheid van de verschillende componenten uit de RCA tabel ten opzichte van elkaar. Het proces model zou namelijk rommelig en onoverzichtelijk worden als alle informatie uit de RCA tabel in het proces model zou worden weergegeven. Het is dus belangrijk om een selectie te maken om de besluitvormers op overzichtelijke en begrijpelijke manier de juiste informatie te presenteren. Het derde onderdeel evalueert of u de toevoeging van status symbolen aan elementen uit het procesmodel waardeert. Mits u dit waardeert, wordt u gevraagd het gebruik van de status symbolen te definiëren voor de top 3 die u hebt aangegeven bij onderdeel 2. Vanaf hier begint de vragenlijst. Succes!

In de vragenlijst wordt u verzocht om telkens maar één antwoord te geven op een vraag.

0. **Over welke periode wilt u het liefst de (financiële) informatie gepresenteerd krijgen?**

<table>
<thead>
<tr>
<th></th>
<th>Per week</th>
<th>Per maand</th>
<th>Per half jaar</th>
<th>Per jaar</th>
<th>Anders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

0.1. **Indien ‘anders’ hebt geantwoord, geef aan voor welke periode u het liefst de (financiële) informatie krijgt gepresenteerd:**

Per ..........................................................................................................................................................

De informatie in de volgende onderdelen moet u voor de periode bekijken die u hierboven hebt beantwoord.
### Onderdeel 1

Het wordt geadviseerd om eerst alle componenten aan (financiële) informatie te bekijken voordat u antwoord geeft, om op die manier een goed beeld te krijgen van de verschillende mogelijkheden. Dit onderdeel meet hoe belangrijk u de volgende (financiële) informatie vindt in uw besluitvorming op een schaal van 'helemaal niet belangrijk' tot 'heel belangrijk'. Probeer zo stellig mogelijk te zijn in uw antwoorden. In het cursief blauw wordt de categorie weergegeven waarop de component aan (financiële) informatie betrekking heeft.

**Beschikbare (financiële) informatie van een activiteit:**

1.1. **De tijd die vereist is voor het uitvoeren van een activiteit:**

   Voorbeeld: Het opstellen van een offerte duurt 2 uur.

<table>
<thead>
<tr>
<th>Helemaal niet belangrijk</th>
<th>niet belangrijk</th>
<th>neutraal</th>
<th>belangrijk</th>
<th>heel belangrijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

1.2. **Het aantal keer dat een activiteit wordt uitgevoerd:**

   Voorbeeld: Een offerte wordt vijf keer per maand opgesteld.

<table>
<thead>
<tr>
<th>Helemaal niet belangrijk</th>
<th>niet belangrijk</th>
<th>neutraal</th>
<th>belangrijk</th>
<th>heel belangrijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

1.3. **De totale tijd die aan een activiteit wordt besteed bij DOE-MEE:**

   Voorbeeld: Het opstellen van offertes duurt (2 uur maal 5 keer in de maand) tien uur in totaal per maand.

<table>
<thead>
<tr>
<th>Helemaal niet belangrijk</th>
<th>niet belangrijk</th>
<th>neutraal</th>
<th>belangrijk</th>
<th>heel belangrijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

1.4. **Het totaal aan directe kosten van een activiteit:**

   Voorbeeld: Het opstellen van offertes heeft €300 aan directe kosten per maand.

<table>
<thead>
<tr>
<th>Helemaal niet belangrijk</th>
<th>niet belangrijk</th>
<th>neutraal</th>
<th>belangrijk</th>
<th>heel belangrijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

1.5. **Het totaal aan indirecte kosten van een activiteit:**

   Voorbeeld: Het opstellen van een offerte heeft €600 aan indirecte kosten per maand.

<table>
<thead>
<tr>
<th>Helemaal niet belangrijk</th>
<th>niet belangrijk</th>
<th>neutraal</th>
<th>belangrijk</th>
<th>heel belangrijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

1.6. **De totale kosten (indirect en direct) van een activiteit:**

   Voorbeeld: Het opstellen van offertes heeft (€300 en €600) €900 aan totale kosten per maand.

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<tr>
<th>Helemaal niet belangrijk</th>
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<th>neutraal</th>
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Beschikbare (financiële) informatie van een middel:

1.7.  De vaste en variabele kosten van een werkfunctie of systeem volgens de administratie:
Voorbeeld: De commercie heeft €700 aan vaste kosten en €500 aan variabele kosten per maand.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.8.  De totale tijd die een werkfunctie of systeem besteedt aan activiteiten van het proces:
Voorbeeld: De commercie besteedt 50 uur in totaal aan activiteiten voor de DOE-MEE service.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.9.  De totale kosten van een werkfunctie of systeem in DOE-MEE:
Voorbeeld: De commercie kost €1300 in totaal door het uitvoeren van activiteiten voor de DOE-MEE service.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.12. De beschikbare capaciteit van een werkfunctie of systeem:
Voorbeeld: De commercie bestaat uit twee werknemers die 20 en 40 uur werken in de week, oftewel de capaciteit
van de werkfunctie commercie is 60 uur.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.13. De verhouding (in %) tussen de beschikbare capaciteit en gebruikte capaciteit van een werkfunctie
of systeem:
Voorbeeld: De commercie besteedt 80% van de tijd actief aan activiteiten voor DOE-MEE.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.14. De kosten voor de ongebruikte capaciteit van een werkfunctie of systeem binnen DOE-MEE:
Voorbeeld: De commercie kost €325 (20% van de capaciteit) voor niet werken tijdens toegekende DOE-MEE
werktijd.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk

1.15. De kosten per eenheid van een werkfunctie of systeem in het proces (de som van de vaste en
variabele kosten van een werkfunctie of systeem gedeeld door de beschikbare capaciteit):
Voorbeeld: De commerciekost €30 (€1200/60 uur) per uur in het DOE-MEE proces.

Helemaal niet belangrijk niet belangrijk neutraal belangrijk heel belangrijk
**Overige beschikbare informatie:**

1.16. **De totale kosten voor het DOE-MEE proces:**

   Voorbeeld: Alle componenten in het DOE-MEE proces kosten in totaal €20.000 per maand.

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1.17. **De totale inkomsten van het DOE-MEE proces** (deze inkomsten worden niet opgesplitst in direct en indirect en kunnen ook niet aan individuele activiteiten of middelen worden toegekend):

   Voorbeeld: De inkomsten voor het DOE-MEE proces zijn €21.000 per maand.

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1.18. **De kans (in %) dat het proces bij een splitsing een bepaald pad kiest (zie figuur):**

   Voorbeeld: Nadat de controle (zie figuur) is gedaan, is er in 70% van de gevallen geen verschil en in 30% van de gevallen wel een verschil gedetecteerd.

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<th>Helemaal niet belangrijk</th>
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![Diagram](image-url)
Onderdeel 2

Dezelfde componenten aan (financiële) informatie van eerste twee categorieën uit onderdeel 1 worden nu opnieuw geëvalueerd. In dit onderdeel wordt de relatievolle belangrijkheid van de verschillende componenten uit de RCA tabel ten opzichte van elkaar onderzocht. U wordt gevraagd om op de stippenlijnen de verschillende componenten te rangschikken in belangrijkheid ten opzichte van elkaar. Als er dus 6 componenten zijn dan rangschikt u de componenten vanaf nummer 1 t/m nummer 6, waarbij nummer 1 de belangrijkste en nummer 6 de minst belangrijke component aanduidt. U mag dus niet eenzelfde nummer meerdere malen toekennen binnen een categorie. In het cursief blauw wordt de categorie weergegeven waarop de component aan (financiële) informatie betrekking heeft.

Beschikbare (financiële) informatie van een activiteit:

2.1. **Rangschik de volgende informatie van nummer 1 t/m 6:**

......... De tijd die vereist is voor het uitvoeren van een activiteit

......... Het aantal keer dat een activiteit wordt uitgevoerd:

......... De totale tijd die aan een activiteit wordt besteed bij DOE-MEE:

......... Het totaal aan **directe** kosten van een activiteit

......... Het totaal aan **indirecte** kosten van een activiteit

......... De totale kosten (**direct en indirect**) van een activiteit

Beschikbare (financiële) informatie van een middel:

2.2. **Rangschik de volgende informatie van nummer 1 t/m 7:**

......... De vaste en variabele kosten van een werkfunctie of systeem volgens de administratie

......... De totale tijd die een werkfunctie of systeem besteedt aan activiteiten van het proces

......... De totale kosten van een werkfunctie of systeem in DOE-MEE

......... De beschikbare capaciteit van een werkfunctie of systeem

......... De verhouding (in %) tussen de beschikbare capaciteit en gebruikte capaciteit van een werkfunctie of systeem

......... De kosten voor de ongebruikte capaciteit van een werkfunctie of systeem binnen DOE-MEE

......... De kosten per eenheid van een werkfunctie of systeem in het proces
Onderdeel 3

In dit onderdeel wordt onderzocht of het gebruik van symbolen in combinatie met (financiële) informatie uw besluitvorming verbetert. Een symbool wordt weergeven als volgt:

Er volgen nu een aantal vragen over dit onderwerp.

3.1. Verbetert het gebruik van symbolen in combinatie met (financiële) informatie uw besluitvorming?

Ja □ Nee □

Ga verder met de volgende vragen als u ‘ja’ bij vraag 3.1 hebt geantwoord.

Symbolen kunnen zowel voor positieve als negatieve terugkoppeling zorgen. Bij positieve terugkoppeling kan een groen vinkje gebruikt worden om aan te geven dat een element goed scoort op een bepaald criterium. Een oranje driehoek met een uitroepteken kan daarentegen fungeren als symbool voor de negatieve terugkoppeling over een element dat niet goed scoort op een bepaald criterium. Voor de twee voorbeeldfiguren hieronder is gedefinieerd dat de activiteitskosten lager gelijk aan €1000 een groen vinkje krijgen en activiteitskosten hoger dan €1000 een oranje driehoek met uitroepteken.

Hierover volgen nu een aantal vragen.

3.2. Ziet u graag positieve terugkoppeling in uw procesmodel?

Ja □ Nee □

3.3. Ziet u graag negatieve terugkoppeling in uw procesmodel?

Ja □ Nee □

Als u bij vraag 3.2 of vraag 3.3, of beide, ‘ja’ hebt geantwoord gaat u verder met de volgende vragen.
De toekenning van symbolen aan elementen kan gedefinieerd worden door het gebruik van de volgende regels:

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U wordt nu gevraagd om bij de top drie, die u zelf hebt aangegeven in onderdeel 2, het gebruik van symbolen te definiëren met gebruik van de regels uit bovenstaande tabel. U wordt verzocht om de regels te definiëren voor de symbolen die u bij vragen 3.2 en 3.3 met ‘ja’ hebt beantwoord.

*Als voorbeeld: De totale kosten (indirect en direct) van een activiteit krijgen het volgende symbool als:*

- Kleiner dan of gelijk aan €1000/kleiner dan 10% van de totale kosten voor het proces/etc.
- Groter dan €1000/groter dan 30% van de totale kosten voor het proces/etc.

3.4. **Top 3 aan (financiële) informatie van een activiteit (zie antwoorden in onderdeel 2):**

1. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................

2. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................

3. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................

3.5. **Top 3 aan (financiële) informatie van een middel (zie antwoorden in onderdeel 2):**

1. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................

2. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................

3. ✔️ ......................................................................................................................................................
   ✔️ ......................................................................................................................................................
Welke (financiële) informatie of combinatie van informatie uit deze vragenlijst zou u daarnaast graag willen terugzien in het procesmodel als verdere ondersteuning van uw besluitvorming?

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De vragenlijst is hier ten einde. Bedankt voor uw medewerking.
Appendix VI: Organizational structure Ploos Energieverlening