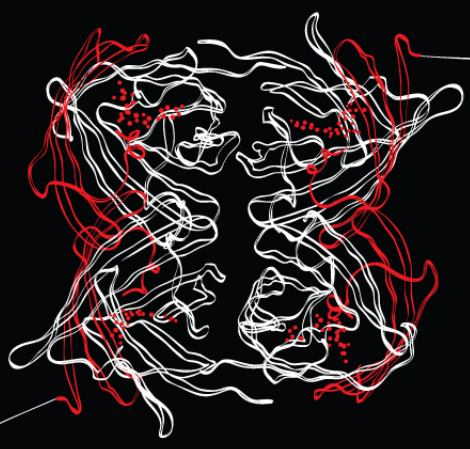
MASTER THESIS BY ARJAN J. STARING

Business Models & Business Cases For Point-Of-Care Testing



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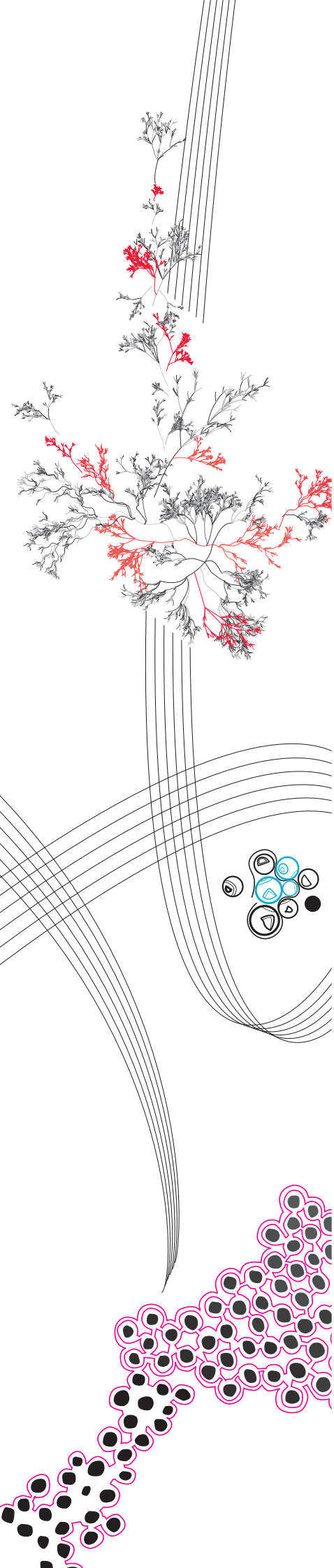

MASTER THESIS

Business Models & Business Cases For Point-Of-Care Testing

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ABSTRACT

Point-Of-Care Testing enables clinical tests at or near the patient with the assumption that test results will be available instantly or in a very short time frame to assist caregivers with immediate diagnosis and/or clinical intervention. The goal of Point-Of-Care Testing (POCT) is to provide accurate, reliable, fast and cost-effective information about patient condition. POCT can be part of the solution to the rising healthcare and welfare costs in the Netherlands and other developed countries without any loss of healthcare quality. POCT shortens the time for clinical decision-making about additional testing or therapy, as transport and preparation of clinical samples no longer causes delays, and biochemical-test results are available at the point of care rapidly. Overall POCT may improve medical outcome and lower costs.

Assessing the viability of POCT was done by developing business models and business cases. This has been done by developing two methods to construct three business models for each method. The "As is" situation has been modelled without POCT and several "To be" situations with POCT and the automated processing of POCT test results by MobiHealth. MobiHealth is a Dutch company that was founded in 2007. The company's roots lie in the European projects MobiHealth and HealthService24. In these projects, a prototype for mobile telemonitoring was designed, tested and clinically validated in several European countries. MobiHealth has developed a service to automatically process POCT test results. The business models are used to create business cases upon which an analysis is performed to assess the viability of POCT.

Development of the business models by using the designed methods proved to have an impact on the resulting business cases. By adding new steps to an existing method we were able to further quantify the business model and improve understanding by providing a visualisation of the business model. Still some pitfalls exists in the used methods, mainly in terms of scope and level of detail to which the methods are applied to the MobiHealth case. Various visualisation tools have been used to analyse the effects, risks and cost & benefits elements of the business case. This provided new insights and understanding in the dynamics of the business models to draw conclusions on the viability of POCT.

POCT viability conclusion shows the four automating the processing of POCT test results by MobiHealth are all viable. POCT allows general practitioners to perform tests in their practice and quickly make clinical discussions. The four business models implement the service of MobiHealth to push the POCT test results to the laboratory eliminating the need for a courier. Two of the business models use existing infrastructure to synchronise back with the information system of the general practitioner. The other two business models integrate the back synchronisation into the MobiHealth service thus eliminating the need for a third party. In one of those business models the responsibility of the laboratory to deploy POCT equipment is shifted towards MobiHealth.

All in all most financial and non-financial benefits are achieved in the business models including the two way integration (automatic processing of POCT test results and the back synchronisation) by MobiHealth, whereas the business models without the back synchronisation pose less risks and are viable as well.

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1. Introduction

1.1 Motivation

In the Netherlands, and other developed countries, healthcare and welfare costs are rising. Solutions need to be found to keep these costs within reasonable limits [12, 13, 16, 30], but without any loss of healthcare quality [15].

Point-Of-Care Testing (POCT) can be part of the solution. The goal of POCT is to provide accurate, reliable, fast and cost-effective information about patient condition [50]. Ehrmeyer and Laessig [20] define POCT as "patient specimens assayed at or near the patient with the assumption that test results will be available instantly or in a very short time frame to assist caregivers with immediate diagnosis and/or clinical intervention".

Already some forms of POCT exists, such as glucose testing and urine dipsticks [5]. These used to be exclusively laboratory tests, but have evolved to focus solely on measuring the most critical parameters of the designed test. By focusing on only a few parameters, the test becomes more specific, faster and the devices smaller [17].

Although many advantages of POCT have been proven, such as fast diagnosis [38], error reduction [18] and reducing hospital stay time of patients [29]. Some researchers point out that POCT may not always be a cost-beneficial development [31].

1.2 Preliminary research

Research has been done by van Dijk [53] preliminary to this research. His research provides a literature study on POCT. Also a stakeholder analysis of the MobiHealth case was performed and possible barriers for market entry have been identified.

His research shows a general trend going towards POCT and interviews presented a positive attitude to developments of this kind. Van Dijk also found more stakeholders through his interviews and worked these into an e^3value model.

1.3 Research goal and objectives

This research aims to provide insight in the viability of POCT as part of the solution to the rising healthcare and welfare costs. Business models and business cases for POCT will be constructed to provide this insight. Therefore the goal and main research question is:

> **"What are viable business models and business cases for Point-Of-Care Testing?"**

To answer the main research question, it is separated into the following objectives and research sub-questions.

Objective 1 Develop the derivatives of the Business Modelling Method for POCT

a. What is Point-Of-Care Testing (POCT)?

b. What is the Business Modelling Method (BMM)?

c. What specific methods should be used in the derivatives of BMM?

Objective 2 Create business models by applying the derived Business Modelling Methods to the MobiHealth case

a. What methods, besides the derivatives of BMM, are needed to create business models?

Objective 3 Develop business cases by apply the Business Case method for Business Models (BM2BC) and a sensitivity analysis method

a. What is the Business Case method for Business Models (BM2BC)?

b. What sensitivity analyses method is suitable for business cases?

Objective 4 Analyse the business cases

a. What method or tools of analysis are suitable to analyse business cases?

Objective 5 Evaluate the derived Business Modelling Methods and their resulting business models and business cases

a. What effects did the methods have on the resulting business models?

b. What effects did the methods have on the resulting business cases?

1.4 Research model and methodology

In order to reach the research goal, a research model is created to help structure this research and outline a path. The research model is created using a method developed by Verschuren et al. [55]; the result can be found in Figure 1.1. The blue boxes represent the methods to be used whereas the green boxes represent the (intermediate) results.

The research model is split in four phases following the phases of the research design cycle of the design science methodology as developed by Wieringa [59].

To develop the business models the Business Modelling Method [36] will be used. Bolscher [8] and Sweet [52] have shown the usefulness of the Business Modelling Method (BMM) in their research. It was concluded that BMM is applicable in a case study in Dutch elderly care by searching for criteria in the literature that can judge its applicability and usefulness [8].BMM has also proven useful to develop business models for a R&D organisation [52]. This has been done by tailoring BMM to suit to the specific R&D organisation. It was concluded that the method encouraged for continuous improvement while working with the method [52].

BMM does not specify which specific methods should be used in each step, but rather what type of methods should be be used. For instance Meertens et al. propose the use of a cost accounting method in step four and listed the Activity-based-costing method as an example. Depending on the context other methods can be used in to implement BMM.

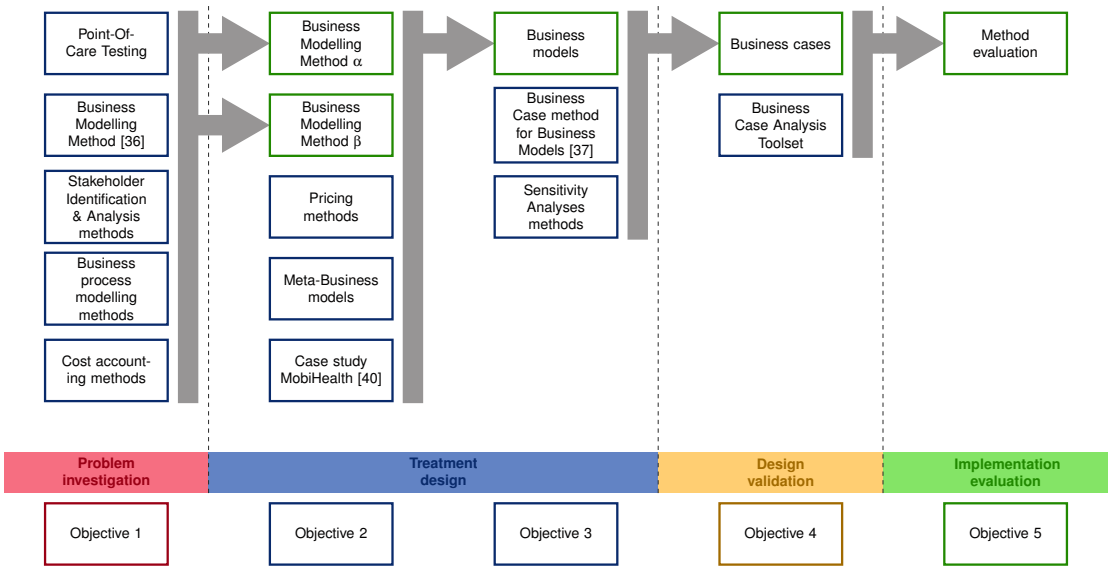

Figure 1.1: Research model

The specific methods to be used in BMM in this research will be chosen for their suitability for POCT. This research will develop two derivatives of BMM namely BMM α and BMM β. By developing more derivatives of BMM we are able to develop more business models as well as more business cases and study the impact of each method on the result.

Suitable methods need to be found in order to develop BMM α and BMM β. Firstly a background on POCT will be given. The preliminary research as discussed in Section 1.2 will help provide this background. Secondly stakeholder identification and analysis, business process modelling and cost accounting methods will be identified for the POCT context to be used in the BMM derivatives. Since it is not the goal of this research to construct an entire overview of all existing methods mentioned before, only the most common will be considered.

For Objective 2 BMM α and BMM β will be applied to the MobiHealth [40] case. A case study should be considered when one or more of the following statements is true [60]:

1. The focus of the study is to answer “how” and “why” questions
2. You cannot manipulate the behaviour of those involved in the study
3. You want to cover contextual conditions because you believe they are relevant to the phenomenon under study
4. The boundaries are not clear between the phenomenon and context

For this research the first and third statements are true. For the first three steps of BMM we need to answer several “how” and “why” questions in order to determine the stakeholders involved, their relationships and their activities. The third statement seems quite broad, but the “phenomenon(s) under study” are BMM α and BMM β; and the “contextual conditions” relates to POCT.

The type of case study research to be conducted guides the overall study purpose. Yin [60] categorises case studies as explanatory, exploratory, or descriptive, whereas Stake [51] identifies

case studies as intrinsic, instrumental, or collective. Within the framework of Yin, the case study research is of the explanatory type. This type of case study is used to explore those situations in which the intervention being evaluated has no clear single set of outcomes [60]. According to Stake, the case study research is of the instrumental type as this type of case study provides insight into an issue or helps to refine a theory. This approach should be considered when the case has a supportive role, facilitating the understanding of something else [51]. In our research the case study is to support the application of BMM α and BMM β.

BMM does focus on the cost structure of the to be created business model, however revenue streams are not mentioned. The specifics on how to obtain revenue are within the process models created in step three of BMM, but are not explicitly quantified. Where costs are quantified, revenues need to be quantified as well. Therefore different pricing methods will be used to extend BMM α and BMM β.

The representation of a business model is not specified in BMM. To create a representation of a business model, meta-business models can be used [3]. Two different meta-business models will be chosen to represent the result of BMM α and BMM β. Since it is not the goal of this research to give an entire overview of all existing meta-business models, only the most common will be considered.

The resulting business models from Objective 2 will be used in Objective 3. The goal of Objective 3 is to create business cases based on the developed business models from BMM α and BMM β. This is done by using the Business Case method for Business Models (BM2BC) [37]. BMM mentions two additional steps, one of these steps is further developed in BM2BC. BM2BC is not an extension of BMM, but rather a method to use after BMM to further quantify and compare business models [37].

The business models will also be subject to a sensitivity analyses. A sensitivity analysis can be defined as "the study of how the uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs" [47]. The quantitative part of a business case is a mathematical model, therefore we are able to apply a sensitivity analysis on it. Hamby [25] and Pannell [43] already made an overview of methods in 1994 and 1997 respectively. More recently Saltelli et al. [47] published a book with a detailed description of possible sensitivity analysis methods.

The business cases resulting from Objective 3 will be evaluated and analysed using a business case analysis method. This will be done to complete Objective 4. Using different tools the developed business cases will be analysed and new insights will be revealed.

Lastly to complete Objective 5 the effects of the different methods will be evaluated on the resulting business models and business cases. This will be done by evaluating the process and construction of results during this research.

Figure 1.2 shows the deliverables of the research model (Figure 1.1) per objective and how the deliverables build on each other. Three business models will be constructed per BMM derivative. These business models will serve as options in the business cases. As the selection of specific methods is not yet determined, this figure is not yet complete. The final version can be found in Figure 4.4.

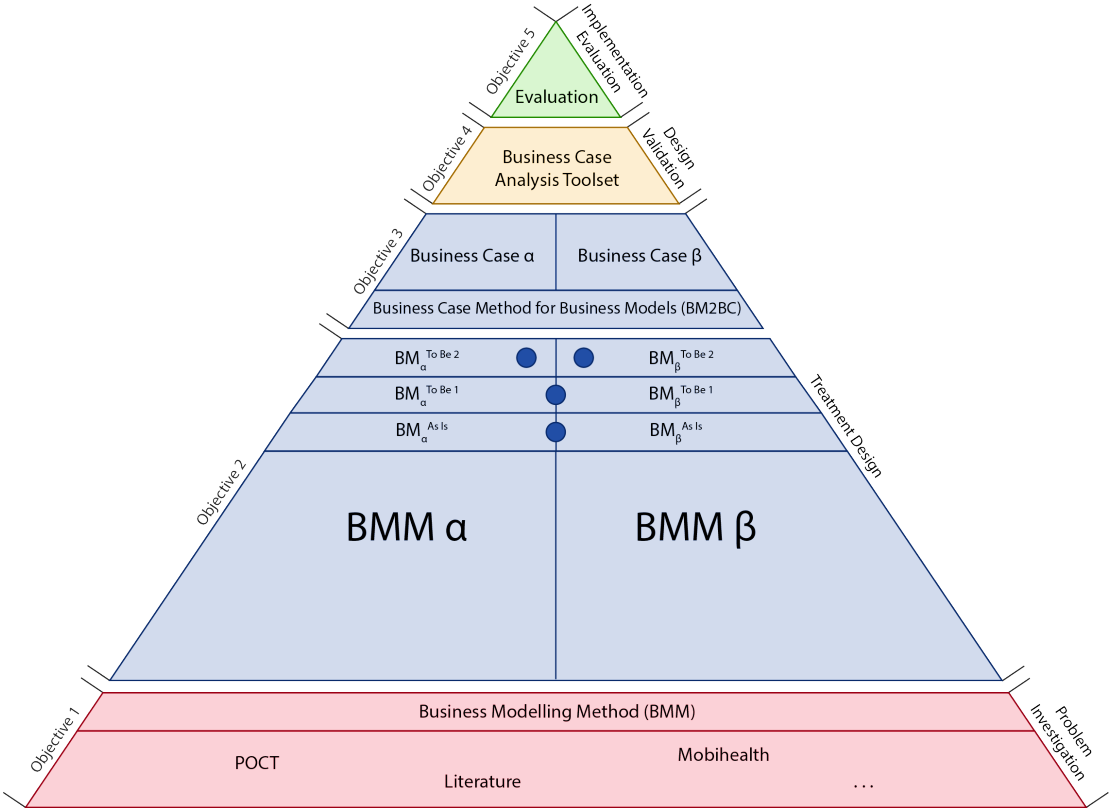

Figure 1.2: Structure deliverables of research model (Figure 1.1)

1.5 Literature research strategy

To find the literature needed for this research, we will use Scopus [49] and Google Scholar [21]. The literature is needed to develop the derivatives of BMM. It is not needed to perform an extensive literature research to overview all existing methods. Therefore the literature databases will be searched with criteria such as “overview”, “comparison”, “history of”, “methods” or “techniques” to overview the most used, for example, pricing methods.

Methods found will also be searched with in combination with the criteria “alternative(s)”, in order to find methods who either aim to be a successor or a better fit in a certain situation.

The number of citations of a source as well as the year of publication will be taken into account to determine the trustworthiness of the source. Articles, proceedings, etc. will me valued above sketchy websites. Publications from authoritative organisations will be subject to critical reading as not to include a biased opinion of an author.

2. Point-Of-Care Testing (POCT)

What is Point-Of-Care Testing (POCT)? To start this research, this question will be answered in this chapter. This also answers the first research sub-questions and opens the path in Objective 1 to develop the derivatives of the Business Modelling Method for POCT.

As stated in Section 1.2 van Dijk [53] has recently done an extensive literature study on POCT. Therefore his literature study will be used in this chapter to gain insight in the current state of POCT.

In the Netherlands, and other developed countries, healthcare and welfare costs are rising. Solutions need to be found to keep these costs within reasonable limits [12, 13, 16, 30], but without any loss of healthcare quality [15].

Point-Of-Care Testing (POCT) can be part of the solution. The goal of POCT is to provide accurate, reliable, fast and cost-effective information about patient condition [50]. Ehrmeyer and Laessig [20] define POCT as "patient specimens assayed at or near the patient with the assumption that test results will be available instantly or in a very short time frame to assist caregivers with immediate diagnosis and/or clinical intervention".

Already some forms of POCT exists, such as glucose testing and urine dipsticks [5]. These used to be exclusively laboratory tests, but have evolved to focus solely on measuring the most critical parameters of the designed test. By focusing on only a few parameters, the test becomes more specific, faster and the devices smaller [17].

Although many advantages of POCT have been proven, such as fast diagnosis [38], error reduction [18] and reducing hospital stay time of patients [29]. Some researchers point out that POCT may not always be a cost-beneficial development [31].

From an historical perspective Altieri and Camarca [5], Hale and Kost [24] and Luppa et al. [35] provide an overview of developments in POCT.

Altieri and Camarca [5] predict POCTwill likely become the standard of care in the near future, but state that successful implementation will depend on cooperation between the central laboratory, information systems, and operator personnel. Luppa et al. [35] and Hale and Kost [24] differentiate clinical testing and personal testing and see possibilities of POCT extending to other areas.

According to Luppa et al. [35] POCT shortens the time to clinical decision-making about additional testing or therapy, as delays are no longer caused by transport and preparation of clinical samples, and biochemical-test results are rapidly available at the point of care. Luppa et al. [35] and Hale and Kost [24] suggest improved medical outcome and lower costs maybe ensured by POCT

Visser et al. [57] relate to older diabetes patients using POCT and their experiences with the technology. They give a good overview of POCT in practice and user experience with the technology. They show both positive and negative sides of the user experience with POCT and conclude the positives outweigh the negatives.

Middendorf [38] state that when doctors used POCT, results were available in less than 30 minutes over 80% of the time and under an hour 98% of the time. In comparison, results from the hospital laboratory were available under one hour only 50% of the time.

Plebani [45] is concerned for overly optimistic adoption of POCT and calls for careful consideration before adopting it. St-Louis [50] gives a detailed overview of pros and cons of POCT and draws the conclusion that advantages depend on acceptable analytical performance in comparison with central laboratory methods and in relation to clinical criteria. Atypical specimens pose a problem to POCT, but, according to St-Louis [50], recognition of problem areas is driving continuous improvement in POCT.

3. Developing BMM derivatives

What is the Business Modelling Method (BMM) and what specific methods should be used in the derivatives of BMM? Those are the second and third (and last) research sub-questions of Objective 1. By answering those questions Objective 1 will be completed.

This chapter starts by briefly explaining BMM (Section 3.1). In Section 3.2 the derivatives of BMM will be developed. These derived methods will be tailored to suit the POCT context discussed in the previous chapter (Chapter 2).

3.1 Business Modelling Method (BMM)

In order to develop the BMM derivatives an understanding of BMM is required. This section will briefly explain the Business Modelling Method (BMM) and so answer the second research sub-question of Objective 1.

Meertens et al. [36] argue current business modelling is more of an art than a science. They propose the Business Modelling Method (BMM) as to provide a structured method to create business models in a repeatable manner. The method consists of the following steps:

Step 1 Identify roles
Identifying the relevant parties (i.e. roles) involved in a business model.

Step 2 Recognize relations
Identify the interactions and relationships between roles. Assume some exchange of value of some kind when roles interact with each other [36].

Step 3 Specify activities
Every role-relationship consists of at least one interaction between two roles, requiring activities by both roles. This is the first qualitative specification of the business model.

Step 4 Quantify model
By obtaining numbers on cost and volume of the activities, this step allows for the qualitative model to turn into a quantitative model.

The resulting business model is suitable for analysis of the current situation. It can also form the basis for further predictions, such as business cases, scenarios, and alternative innovations. Two extra steps are discussed in the paper to develop these innovations and analyse alternatives, but these steps are not part of the method to create business models [36].

BMM specifies types of methods to be used in a certain order. Every step of BMM is supported by a type of method. It is up to the user of BMM to decide which specific methods are used for each step suitable for his or her situation. Table 3.1 shows an example of possible methods to use within BMM.

Table 3.1: Example implementation BMM; copied from [36]

Step	Inputs	Techniques or Tools	Deliverables
Identify Roles	Documentation, domain literature, interviews, experience, previous research	Stakeholder analysis [46]	Role list
Recognize Relations	Role list, Stakeholder map, value exchanges	e^3value [22]	Role-relation matrix
Specify Activities	Role-relation matrix, Role list, business process specifications	BPM methods, languages and tools	List of activities
Quantify Model	Process specifications, accounting systems and annual reports	Activity based costing Total cost of the business	business model

Table 3.2: Methods for step one (Identify Roles) of BMM derivatives (BMM α and BMM β)

	BMM α	**BMM β**
Step	Identify Roles	
Method	Stakeholder analysis [46]	

3.2 Derivatives of BMM

As the previous section has given a overview of BMM, this section will develop the derivatives of BMM. This will answer the third and last research sub-question of Objective 1 and forms the end result to complete Objective 1. The derivative methods will be tailored to the POCT context discussed in Chapter 2.

Two methods will be derived, called BMM α and BMM β. Both will have different implementing methods to create business models. By using the same method (BMM) but with a different implementation it allows for comparison and evaluation. The resulting methods BMM α and BMM β can be found in table 3.8.

3.2.1 Step 1: Identify Roles

This section will select the method used in the first step of the BMM derivatives. The first step aims to identify all relevant roles. The result can be found in Table 3.2.

To identify relevant roles Meertens et al. [36] suggest the use of a stakeholder identification method. Mitchell et al. [39] have two definition on what a stakeholder is. Their broad view on a stakeholder is broad enough to, as they state, “include virtually anyone” to be a stakeholder. The narrow definition of a stakeholder is given as “a group on which the organisation is dependent for its continued survival” [39].

Table 3.3: Methods for step two (Recognize Relationships) of BMM derivatives (BMM α and BMM β)

	BMM α	**BMM β**
Step	Recognize Relationships	
Method	e^3value [22]	

van Dijk [53] used a stakeholder analysis described by Pouloudi [46] and categorised it using the model of Alexander [4]. Meertens et al. [36] also suggest the method of Pouloudi to be used in the first step. For this research the results of van Dijk [53] will be used, therefore both derivatives will use the stakeholder analysis described by Pouloudi [46].

The stakeholder analysis of Pouloudi consists of three stages:

First stage Mapping "obvious" stakeholders. Low domain knowledge, single entry point.

Second stage Conducting first round of interviews and doing a literature review.

Third stage Conferences, further interviews, more in-depth searching.

Each of these stages gradually add more insight into the research subject and so give a more complete overview of stakeholders involved [46].

Using the narrow definition of stakeholders by Mitchell et al. [39] and the method of identification by Pouloudi [46], we are able to complete the first step of BMM.

To limit the search for stakeholders, only stakeholders in the first three layers of the onion model of Alexander [4] will be included. This model helps divide the stakeholders into relevant categories. It was developed to identify human roles in system development and consists of four onion-like layers.

The kit The hardware and software of the system. There are no humans in this layer.

Our system The kit and its operators and operation rules.

The containing system Our system plus any human beneficiaries of our system.

The wider environment The containing system plus any other stakeholders.

Alexanders beautifully states: "each layer bigger than the one before, but also containing all layers inside it" [4]. We will limit the inclusion of stakeholders to the first three layers as the "wider environment"-layer does not fit the narrow definition of Mitchell et al. [39].

3.2.2 Step 2: Recognize Relationships

This section will select the method used in the second step of the BMM derivatives. The second step aims to recognise and characterise the relationships among the roles identified in the first step (Section 3.2.2). The result can be found in Table 3.3.

During the identification of roles in step one (Section 3.2.1), relationships among roles become clear. Step two aims to provide an overview of the relationships between roles. assuming an exchange of value of some kind when roles interact with each other [36].

Table 3.4: Example role-relationship matrix

	role α	role β	role γ	roleδ
role α		relationship α-> β		
role β	relationship β-> α			
role γ				
role δ				

Table 3.5: Methods for step three (Specify Activities) of BMM derivatives (BMM α and BMM β)

	BMM α	**BMM** β
Step	Specify Activities	
Method	BPMN [11]	EPC [48]

Where value is exchanged between roles, a process or activity is needed to facilitate that exchange. Step two prepares for step three and follows naturally from the first step. The result can be as simple as a role-relationship matrix. In such a matrix all roles are indicated on both axes and the cells represent all possible relations among the roles. The axes can represent the direction of the exchange. Table 3.4 shows an example of a role-relationship matrix.

To visualise the relationships among the roles we considered using the Unified Modeling Language (UML) [27] specifically the class diagram notation. The main advantage is it allows for easy conversion to an activity diagram which can be used in step three. Not being able to visualise the exchange of value, but solely the relationship; is for the purpose of this step considered a disadvantage of UMLs class diagram. Since the relationships themselves can be seen in the role-relationship matrix, new insights can be gained by visualising the exchange of value.

The e^{3}value methodology has been developed to model a value web. Such a model consists of actors who create, exchange, and consume things of economic value [22]. It has been used to model value webs in various industries, e.g. the music, finance, internet service provisioning, news and energy industry [22]. e^{3}value has proven its usefulness and can serve in our goal to visualise relationships among roles identified in the first step. Therefore e^{3}value will be used in the seconds step of the derivatives of BMM.

Figure 3.1 shows an example e^{3}value-model including a legend. The model shows the exchange of value between actors and the dependencies between different value exchanges. The example shows the money of the shopper is exchanged for goods at the store and the store buys its goods at the wholesaler. The wholesaler in its turn receives its goods from the manufacturer. Between all actors money is exchanged for goods, but this can be anything as long as it holds value to one of the actors.

Van Dijk [53] has used the e^{3}value methodology in his paper to visualise value exchanges with and without MobiHealth [40].

3.2.3 Step 3: Specify Activities

This section will select the method used in the third step of the BMM derivatives. The third step aims to specify the activities needed for the roles (Section 3.2.1) to maintain their relationships and value exchanges (Section 3.2.2). The result can be found in Table 3.5.

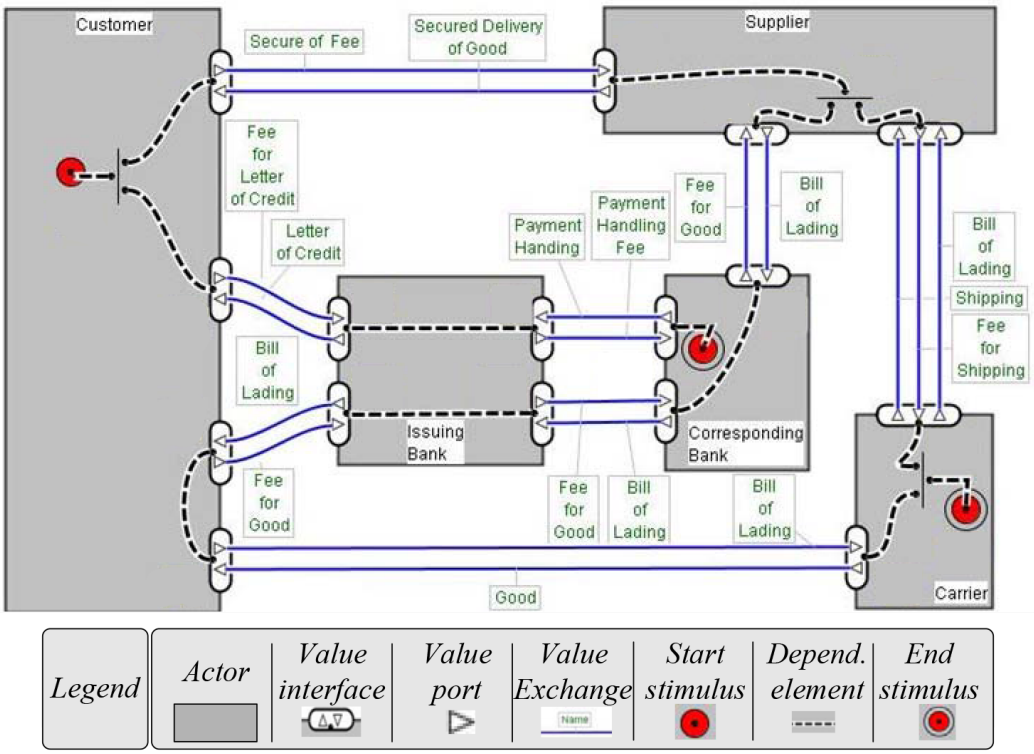

Figure 3.1: Example e^{3}value-model; copied from [22]

The relationships identified in the previous step help specify activities. The activities reveal what must/should happen for the business to function properly. Each of the relations in the role-relation matrix consists of at least one interaction between two roles, requiring activities by both roles [36].

Lin et al. [32] analysed 10 Business Process Modelling Languages (BPML) and derived eight generic concepts: activity, resource, behaviour, event, information, relation, agent and entity. List and Korherr [33] propose a generic meta-model that captures a wide range of process concepts and evaluate seven BPMLs based on this meta-model.

Based on this work the following BPMLs will be used in step three of the derivatives of BMM:

Business Process Modelling and Notation (BPMN) [11] models consist of simple diagrams for both business users and developers. BPMN aims to simplify the understanding of business activity flows and processes. The basic elements of BPMN are flow objects (i.e. events, activities, gateways), connecting objects (i.e. sequence flow, message flow, association), swim lanes and artefacts (e.g. data objects).

Event Driven Process Chain (EPC) [48] has been developed for modelling business processes with the goal to be easily understood and used by business people. The basic elements of EPC are functions and events. Functions model the activities of a business process, while events are created by processing functions or by actors outside of the model.

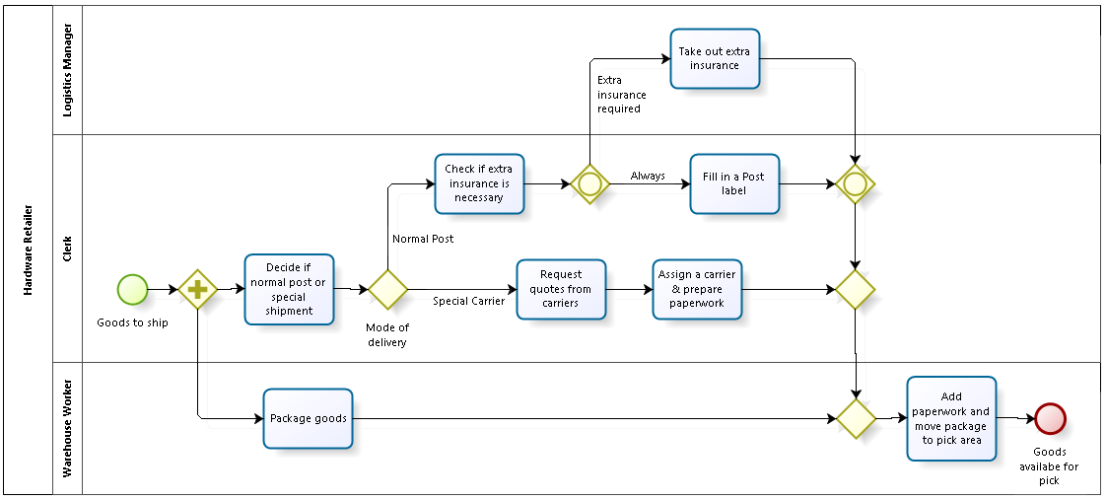

Figure 3.2: Example BPMN model (shipment process of a hardware retailer); copied from [10]

List and Korherr [33] analysed version 1.0 of BPMN. As of March 2011 the current version of BPMN is 2.0 [11]. This research will be using version 2.0. Figure 3.2 shows an example BPMN model, modelling the shipment process of a hardware retailer [10]. BPMN is chosen for BMM α, because not only business people can use the model, but also developers. BPMN allows for easy translation to Business Process Execution Language (BPEL) to help support the business.

Figure 3.3 shows an example EPC model. The model can be extended with data, products, and organisational elements. Such a model is therefore sometimes called an extended event-driven process chains (eEPC) [34]. An eEPC defeats the initial purpose of an EPC, namely the easy understanding and accessibility, by making it more complex. When more (complex) elements are needed in an EPC, a standard such as BPMN would be more suitable. The use of EPC in BMM β is to create an easy to understand model of the activities of the business.

By using BPMN for BMM α, the resulting process models will be extensive and suitable not only for business people, but also developers. BMM β on the other hand will keep is simple by using EPC models allowing for easy understanding by all stakeholders identified in the first step.

3.2.4 Step 4: Quantify Model

This section will select the method used in the fourth step of the BMM derivatives. The fourth step aims to quantify the model using the specified activities in the third step (Section 3.2.3). The result can be found in Table 3.6.

This step helps to see what is happening in more detail and allows for comparison between business models [36]. Numbers on cost and volume of activities are needed to completely overview the costs captured by the business model. These numbers can come from several sources such as accounting systems and (annual) reports. Cost accounting methods can be used when/if not all required numbers are available.

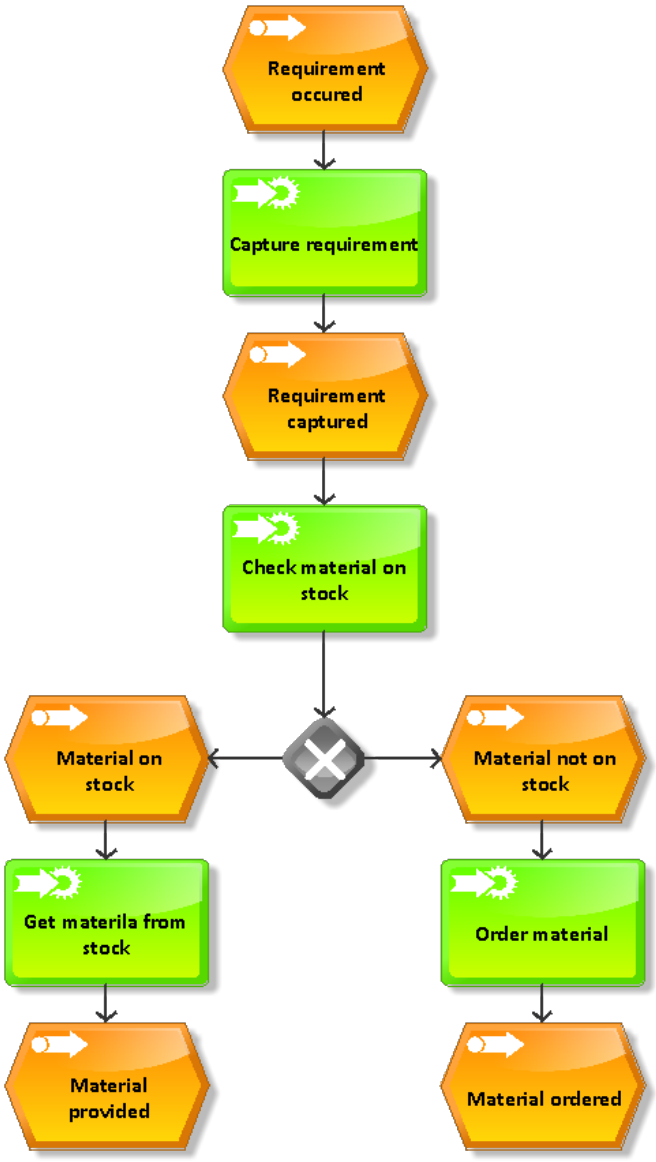

Figure 3.3: Example EPC model; copied from [34]

The origin of numbers depends on whether the “As is”-business model or “future”-business model is modelled. To model the “As is”-business model, numbers from accounting systems and (annual) reports can be taken. To model the “future”-business model cost accounting methods need to be used to estimate the costs.

Cost accounting methods are divided in two types of methods: absorption costing and variable costing. With an absorption costing method, fixed manufacturing overheads are allocated to the products. With a variable costing method, only variable manufacturing costs are assigned to the product; fixed manufacturing costs are regarded as period costs. Both variable and absorption costing methods treat non-manufacturing overheads as period costs [19]. Figure 3.4 graphically

Table 3.6: Methods for step four (Quantify Model) of BMM derivatives (BMM α and BMM β)

	BMM α	**BMM** β
Step	Quantify Model	
Method	Time-driven Activity-Based Costing [28]	Variable costing [19]

shows the differences between variable and absorption costing methods.

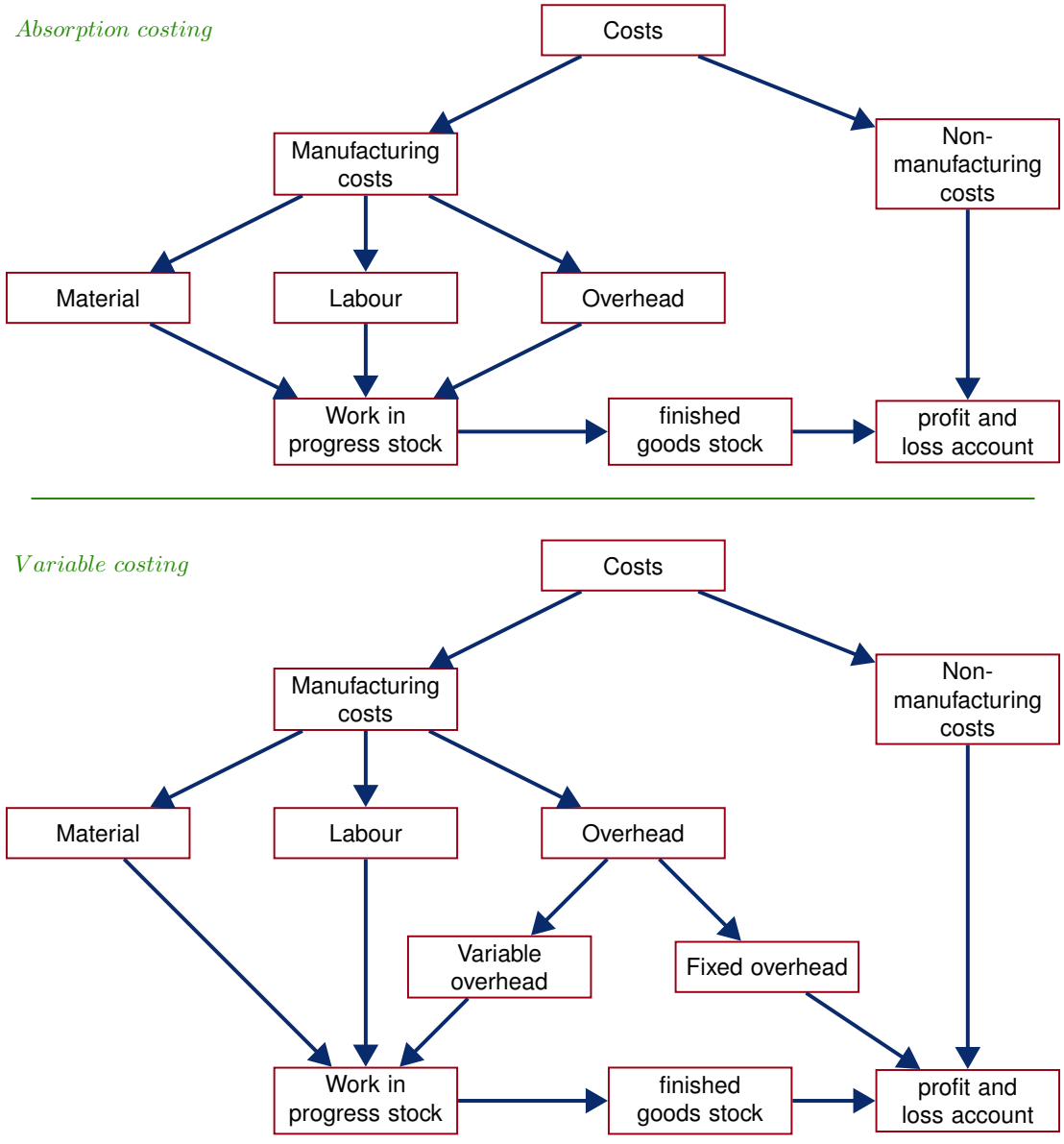

Figure 3.4: Differences between variable and absorption costing methods; copied from [19]

Variable and absorption costing methods both have their advantages and disadvantages. Most

Table 3.7: Example Time-driven Activity-Based Costing; copied from [28]

Activity	Quantity	Unit Time	Total Time	Unit Cost*	Total Cost Assigned
Handle Customer Orders	10.200	40	408.000	$ 32	$ 326.400
Process Complaints	230	220	50.600	$ 176	$ 40.480
Perform Credit Checks	540	250	135.000	$ 200	$ 108.000
Total Used			593.600		$ 474.880
Total Supplied			700.000		$ 560.000
Unused Capacity			106.400		$ 85.120

*Using: Cost per minute $= \frac{\$560.000}{\$700.000} =$ $ 0,80 per minute

advantages and disadvantages are on a financial-technical level. It is important to understand that with variable costing, profit is a function of sales volume, whereas with absorption costing is a function of both sales and production. It is argued that variable costing provides more useful information for decision-making by separating fixed and variable costs. Absorption costing on the other hand avoids fictitious losses being reported when a business relies on seasonal sales with a hight production outside the sales season [19].

The impact of variable and absorption costing on the profit is equal when production and sales are the same. When production exceeds sales, using an absorption costing method will produce higher profits, because the inventory is increasing. On the other hand when sales exceed production, variable costing methods will produce higher profits [19].

Activity-Based Costing (ABC) [9] has been mentioned as a possible method to use in step four [36]. ABC is a type of absorption costing method. But several problems arise when companies attempt to scale up. Maintaining the ABC model, to reflect its changes in activities, processes, products, and customers can be a time and resource consuming activity [28]. To overcome these problems Kaplan [28] proposes Time-driven Activity-Based Costing (TD-ABC) by requiring estimates of only two parameters: (1) the unit cost of supplying capacity and (2) the time required to perform a transaction or an activity. Table 3.7 shows an example of TD-ABC. The total used, supplied and unused capacity statements can be translated in terms of sales, production and inventory to align with what is stated above.

Since ABC and TD-ABC are widely used [19, 28], but ABC has his challenges, we will use TD-ABC in step four of BMM α. As stated before, when production and sales are equal, so will be the profit calculated by using absorption and variable costing methods. Sales and production will likely be the same in the case on which BMM α and BMM β will be applied. Also, absorption costing methods are considered more complex than variable costing methods. Therefore BMM β will be using the variable costing method as described by Drury [19].

3.3 Conclusion

What is Point-Of-Care Testing (POCT)? What is the Business Modelling Method (BMM) and what specific methods should be used in the derivatives of BMM? Those research sub-questions have been answered in Chapter 2 and 3. By doing so the derivatives of the BMM for POCT have been developed and Objective 1 completed. The result can be found in Table 3.8. The derivatives are called BMM α and BMM β.

Table 3.8: Derivatives BMM α and BMM β

Step	**BMM** α	**BMM** β
Identify Roles	Stakeholder analysis [46]	
Recognize Relations	e^3value [22]	
Specify Activities	BPMN [11]	EPC [48]
Quantify Model	Time-driven Activity-Based Costing [28]	Variable costing [19]

By have the first two steps the same, the complexity of the methods will be reduced. Thanks to the limited number of methods used, it becomes easier to trace the origin of differences in the resulting business models and business cases. This allows for better comparison and analysis of the results and gain deeper insight in the influence of the methods. As the first two steps are largely been done by van Dijk [53] (see 1.2), the developed derivatives will use the work of van Dijk and so the same methods. Step three and four are the qualitative and quantitative specification of the business model [36]. By performing the same methods (and therefore having the same outcome) for the first two steps, a solid foundation is guaranteed for business models to be build upon.

4. Extending BMM derivatives

This chapter discusses which methods are needed, besides the derivatives of BMM, to create business models. This will answer the first research sub-question of Objective 2. Objective 2 aims to create business models to applying the derivatives of BMM to the MobiHealth case.

Zott et al. [62], Vermolen [54] and Alberts [2] have done research to a wide range of business models. Zott et al. and Alberts made a list of concepts (i.e. components) in a business model. The list of Alberts reveals BMM is missing some concepts to be able to develop a business model. This chapter will extend the BMM derivatives (BMM α and BMM β) developed in Section 3.2.

4.1 Pricing method

Step four of BMM aims to quantify the model, but Meertens et al. [36] only focus on the costs of the model. They state: "...these numbers form a complete view of the costs captured..." and argue that the specified activities of step three cost resources (i.e. money). The argumentation for step four is reasonable, but a business only spending money will not last long; revenue needs to be generated. Although sales activities will be specified in step three, quantification using cost accounting methods will not be sufficient.

As with step four (Section 3.2.4) numbers on sales and volume of activities are needed to provide a complete overview of the revenue generated by the business model. As in step four, these numbers can come from several sources such as accounting systems and (annual) reports. pricing methods can be used when/if not all required numbers are available.

The origin of numbers depends on whether the "As is"-business model or "To be"-business model is modelled. To model the "As is"-business model, numbers from accounting systems and (annual) reports can be taken. To model the "To be"-business model pricing methods need to be used to determine the price.

Table 4.1 shows the pricing methods used as an extension to the BMM derivatives. As this step helps quantify the business model, this step is called "Quantify model II".

Three approaches can be taken to set a price: cost based, competition based and customer based [1]. The most common used pricing method is cost-plus pricing [19, 23], also known as mark-up pricing. Cost-plus pricing is a cost based pricing method [1]. A limitation of cost-plus pricing is that demand is ignored. The price is set by adding a mark-up to the cost, and this may

Table 4.1: Methods for Step five of BMM derivatives

	BMM α	**BMM β**
Step	Quantify model II	
Method	Cost-plus pricing [19]	Value-based pricing [7]

bear no relationship to the price-demand relationship. It assumes that prices should depend solely on costs [19].

An other frequently used pricing method is value-based pricing [23]. The difference between value-based pricing and cost-plus pricing is “pricing down from value versus pricing up from cost” [23]. Value-based pricing is an customer based pricing method as the added value for the customer is translated into a price [1]. Value-based pricing is setting a price that accurately reflects customers’ perception of value and proposes a process to do so [7]. This process is depicted in Figure 4.1.

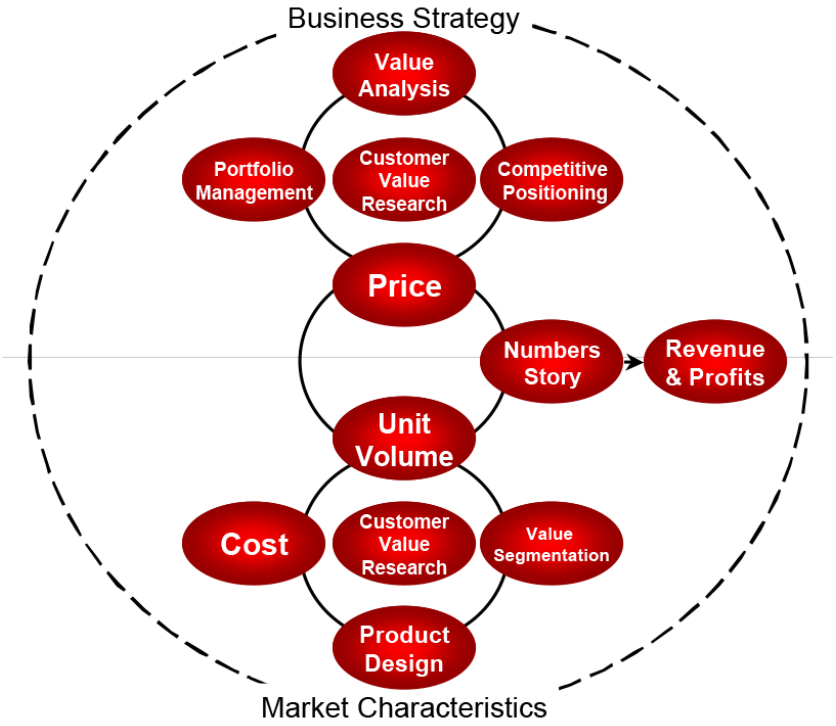

Figure 4.1: Value-based product pricing process; copied from [7]

Figure 4.1 does not have a specific starting point or direction of flow. The goal of the process is to ensure customers receive fair value based pricing, while enabling the supplying company to maintain overall industry price equilibrium [7]. This allows to confidently set the right price, as well as making a realistic prediction of revenue and profitability, which are two objectives of the process.

4.2 Meta-business model

The term business model has been used a lot up until now, but a definition has not yet been given. In this research, the definition of a business model by Osterwalder et al. [42] is used: “A

Table 4.2: Methods for step six of BMM derivatives

	BMM α	**BMM** β
Step	Model Modelling	
Method	BMO [41]	BM Concept [26]

business model describes the rationale of how an organization creates, delivers, and captures value". As such a business model is tailored to a specific organisation.

A meta-business model is the set of concepts and rules that is used to create business models [3]. Therefore a business model developed from this set of concepts and rules is an instance of the meta-business model. BMM only prepares for the creation of a business model in a structured manner. To be able to create a business model with the information gathered using BMM, a meta-business model need to be selected. The meta-business models also dictates the representation of the business model, this is something Meertens et al. [36] do not specify in BMM.

Table 4.2 shows the meta-business model methods used as an extension of the BMM derivatives. As this step help model the resulting business model, this step is called "Model modelling".

Alberts [2] has done an extensive comparison of meta-business models. Based on this comparison Osterwalders Business Model Ontology (BMO) [41] and Hedman and Kalling [26] Business Model Concepts is chosen.

BMO suggest nine so called building blocks to develop a business model. Figure 4.2 shows the Business Model Canvas (BMC) by Osterwalder et al. [42] which visualises the building blocks as well as their relationships.

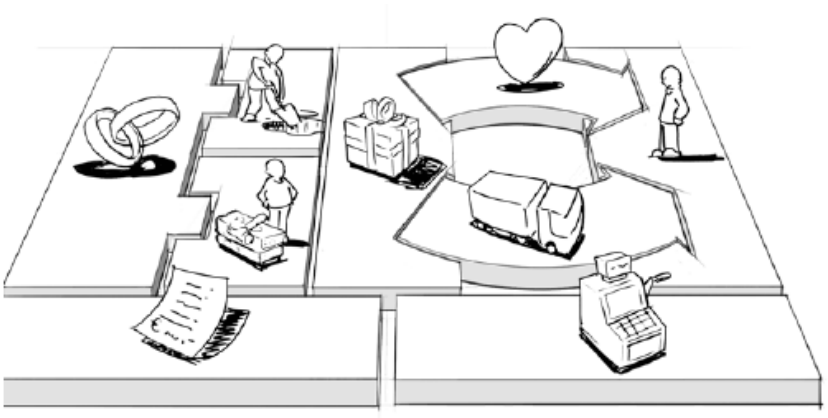

Figure 4.2: Business Model Canvas; copied from [42]

The nine building blocks defined by Osterwalder [41] are:

Customer Segments An organization serves one or several Customer Segments

Value Propositions It seeks to solve customer problems and satisfy customer needs with value propositions

Channels Value propositions are delivered to customers through communication, distribution, and sales Channels

Customer Relationships Customer relationships are established and maintained with each Customer Segment

Revenue Streams Revenue streams result from value propositions successfully offered to customers

Key Resources Key resources are the assets required to offer and deliver the previously described elements...

Key Activities ... by performing a number of Key Activities

Key Partnerships Some activities are outsourced and some resources are acquired outside the enterprise

Cost Structure The business model elements result in the cost structure

Figure 4.3 shows the Business Model Concept (BM Concept) of Hedman and Kalling [26]. The BM Concept includes causally related components: customers, competitors, offering, activities and organisation, resources, and supply of factor and production inputs. The arrows indicate a causal relationship such that product and offerings are transformed from resources through activities. The arrow is bidirectional as activities need resources and resources are useless without activities to utilise them. The model can be studied in two ways: vertically with a causal perspective, and horizontally with a process perspective. This is done because Hedman and Kalling believe the business models has to be managed and developed over time as managers and people on the inside and customers and competitors on the outside continue to evolve [26].

As discussed earlier, BMM only prepares for the creation of a business model. As the result of each step in BMM is used as the input for the next, the meta-business model used in this step needs the result of the previous step. Table 4.3 and Table 4.4 show how the steps of BMM and the step discussed in Section 4.1 serve to be a preparation for the meta-business model.

Table 4.3 shows how BMM prepares for the Business Model Ontology [41]. The Customer Segments building block maps to the identification of roles and recognising relationships steps of BMM as customers is a specific role with predefined relationships. The same holds true for the Key Partnerships, though the specific relationship is not as clear as the customer. Key partners could be suppliers; a supplier has a predefined relationship (i.e. the delivery of goods and services). The Customer Relationships building block deals with the relationship with the customer and so maps to the relationships recognition step. The Channels building block expands that by incorporating the activities to maintain the relationship as well as the delivery of goods and services to the customer. The Revenue Streams and Cost Structure building block deal with the quantification of the business model, here it becomes clear the added step to BMM was necessary to be able to visualise the revenue. Value Propositions combines the two to show what the business does and how it adds value for the customer. The Key Activities building block can not be more clear and maps to the Specify Activities step of BMM. Lastly the Key Resources building block can hold anything that can be considered a resource, such as employees and inventory, therefore it maps to the first three steps of BMM.

Table 4.4 shows how BMM prepares for the Business Model Concept [26]. The Customers, Competitors and Suppliers concepts map to the first two steps of BMM as they are roles with

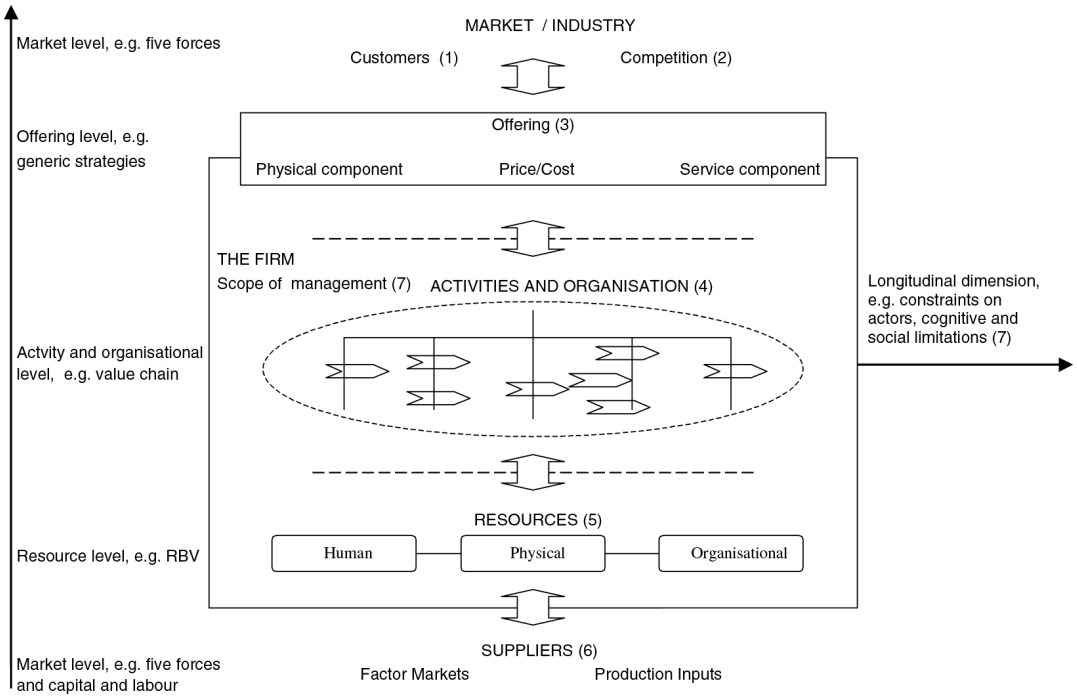

Figure 4.3: Business Model Concept; copied from [26]

predetermined relationships. The Resources concept can hold anything that can be considered a resource, such as employees and inventory, therefore it maps to the first three steps of BMM. The Activities & Organisation concept maps to the Specify Activities step of BMM as this step also outlines the organisation of activities and so covers the entire concept. The Offering concept is the same as the Value Proposition building block of the Business Model Ontology [41] and therefore is a combination of the Specify Activities step and quantification steps. The Scope of management concept covers the dynamics of the business model over time (the cognitive and cultural constraints that managers have to cope with [26]) and so deals the the activities of the organisation. Though the concept itself is broader that the Specify Activities step, it does prepare for the coverage of it.

All of this is in line with the research of Alberts [2]. From what is stated above a mapping could be made between the Business Model Ontology [41] and the Business Model Concept [26], but this would look exactly the same as the result of Alberts [2].

4.3 Conclusion

An answer to the research sub-question has been given by extending the BMM derivatives with missing methods to be able to create business models based on the MobiHealth case. As mentioned BMM misses some concepts to be able to build a business model [2]. Table 4.5 shows the extension of BMM α and BMM β as described in Section 3.2.

Table 4.3: BMM preparation for the Business Model Ontology [41]

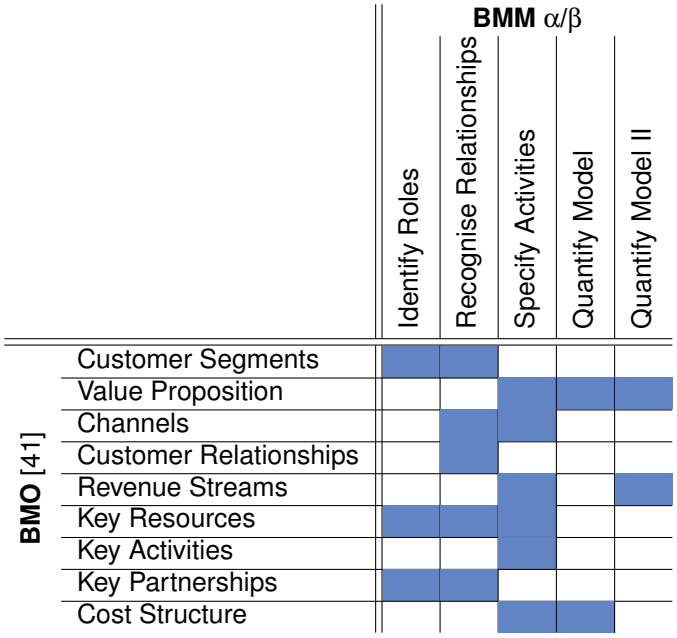

Table 4.4: BMM preparation for the Business Model Concept [26]

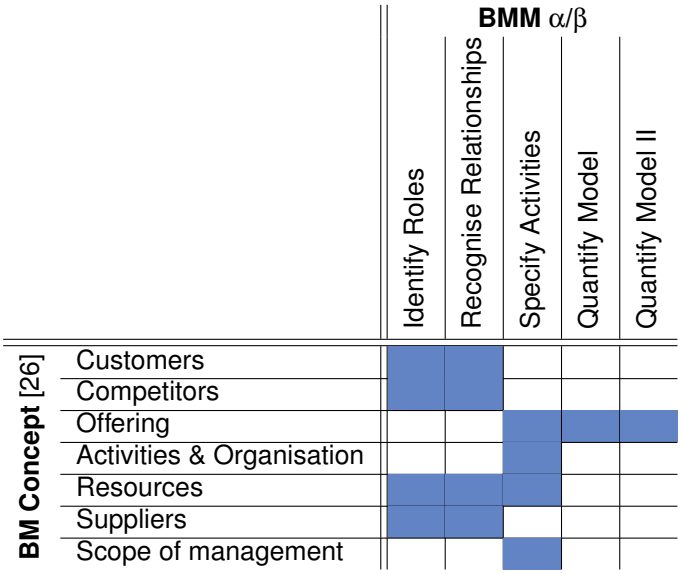

Table 4.5: BMM α and BMM β extensions

Step	**BMM α**	**BMM β**
Quantify Model II	Cost-plus pricing [19]	Value-based pricing [7]
Model Modelling	BMO [41]	BM Concept [26]

Table 4.6: Derivatives BMM α and BMM β (Table 3.8) including extensions (Table 4.5)

Step	**BMM α**	**BMM β**	**Discussed in**
Identify Roles	Stakeholder analysis [46]		Section 3.2.1
Recognize Relations	e^3value [22]		Section 3.2.2
Specify Activities	BPMN [11]	EPC [48]	Section 3.2.3
Quantify Model	Time-driven ABC [28]	Variable costing [19]	Section 3.2.4
Quantify Model II	Cost-plus pricing [19]	Value-based pricing [7]	Section 4.1
Model Modelling	BMO [41]	BM Concept [26]	Section 4.2

Step four of BMM aims to quantify the business model, but is missing the concept of revenue. Section 4.1 discusses the various pricing methods to extend BMM α and BMM β. An extra quantification step has been added to BMM α and BMM β called “Quantify Model II”.

Lastly the argument has been made that BMM prepares for the creation of business models and therefore a meta-business model is needed. Section 4.2 discusses the concept of meta-business models. An extra step has been added to BMM α and BMM β called “Model modelling” and the relation to the previous steps is made clear in Table 4.3 and Table 4.4.

Taking a closer look to Table 4.3 reveals the addition of the “Quantify Model II”-step was necessary to be able to develop a business model using the Business Model Ontology [41]. This underlines the statement that BMM misses the concept of revenue.

The resulting methods BMM α and BMM β including their extensions can be found in Table 4.6. From here on the BMM α and BMM β methods refer to the methods shown in Table 4.6.

As BMM α and BMM β now have been defined, Figure 1.2 can be completed. The final version can be found in Figure 4.4. Figure 4.4 shows the deliverables per research objective as well as the methods used to create the deliverables.

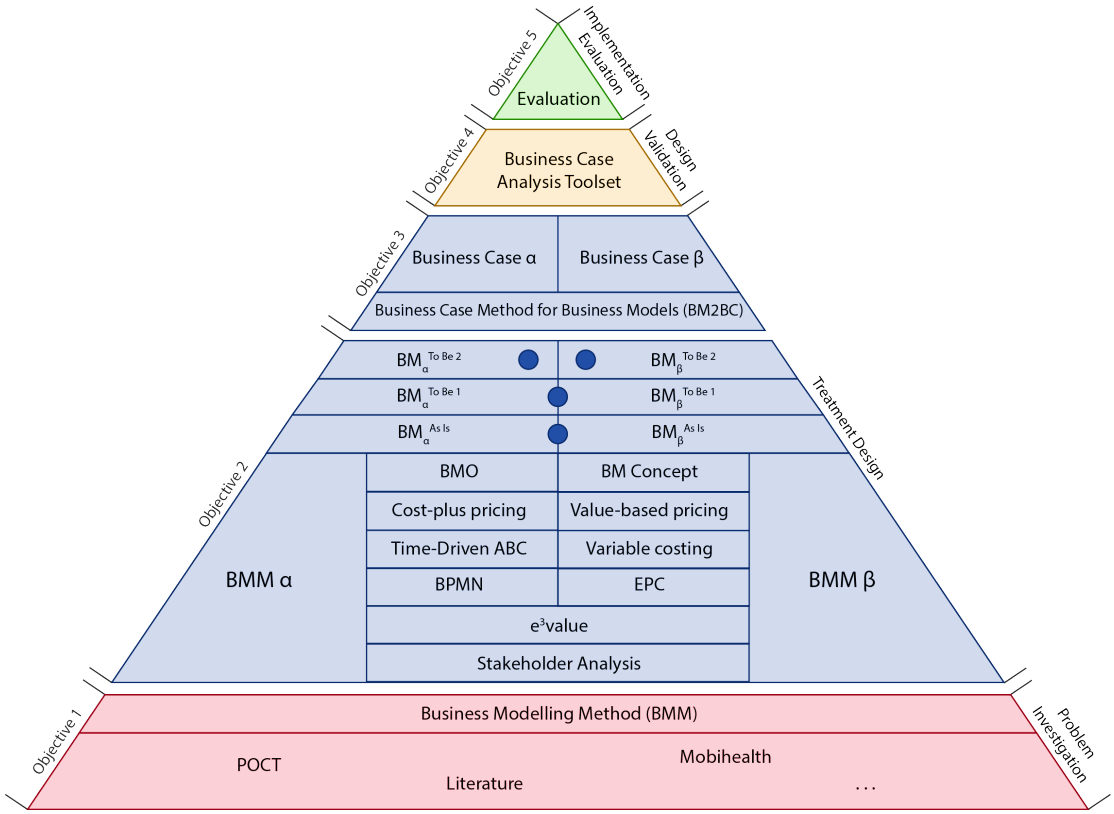

Figure 4.4: Structure deliverables and method selection of research model (Figure 1.1); detailed version of Figure 1.2

5. Case study MobiHealth

Objective 2 states: “Create business models by applying the derived Business Modelling Methods to the MobiHealth case”. The derivatives of BMM (BMM α and BMM β) have been developed and will be applied upon a case. In this research MobiHealth is chosen for a case study. To complete Objective 2 a case study needs to be constructed (Section 5.1) upon which BMM α and BMM β will be applied. The case study is conducted by interviewing the stakeholders identified by van Dijk [53], both in a structured and semi-structured manner.

5.1 MobiHealth

When a sample needs to be taken for a test, this can either be done at the general practice (by the assistant or the general practitioner) or at the laboratory. This could require the patient to make an appointment with the laboratory so a sample can be taken. Whether or not the sample is taken at the laboratory or at the general practice, it needs to be processed by the laboratory. If the sample is taken at the general practice, the sample needs to be transported by courier to the laboratory. Depending on the location of the general practice and the production volume (i.e. number of samples taken), the courier will visit the general practice at least once a day.

When the sample is transported to the laboratory, the laboratory performs the necessary test(s) on it using specialised equipment. The test results are printed; a so called printout. The printouts are entered by hand into the laboratory information system (LIS) and double checked by a second pair of eyes.

The test results entered into the LIS are transported by a third party, such as Zorgmail [61] to the system of the general practitioner (HIS; Huisarts informatie systeem). When the test results are entered into the HIS, the general practitioner is able to check the test results of his/her patients.

Some general practitioners, not all, have POCT equipment in their practice. This allows them to not only take test samples, but also test it using the POCT device. The result is shown on the display of the device and allows for the general practitioner to act upon the result immediately. The test results displayed on the POCT device need to be transcribed on a form or can be printed from the device directly. These forms and printouts are transported by the courier to the laboratory to be entered into the LIS. Sometimes the data is send by email to the laboratory either by scanning it in or the assistant typing the email.

The processing of test results can take up to a couple of days. Performing tests on test samples can, depending on the capacity of the equipment and volume, also take a couple of days. Although the general practitioner has the test results immediate available using the POCT device, still the processing takes a couple of days.

MobiHealth is a Dutch company that was founded in 2007. The company’s roots lie in the European projects MobiHealth and HealthService24. In these projects, a prototype for mobile telemonitoring was designed, tested and clinically validated in several European countries. MobiHealth has developed a service to automatically process the test results of the POCT device. This is done by adding hardware to the POCT device to read the test results and send it to

the computer of the general practitioner. The results are then send directly into the LIS. Using the existing integration between the LIS and HIS, the test results are entered into the HIS. This eliminates the time needed for the courier to take the results to the laboratory and the time it takes to inter the data into the LIS.

Figure 5.1: POCT device with MobiHealth integration; obtained from [40]

Figure 5.1 shows a POCT device with the hardware integration of MobiHealth. The blue device at the left is a firefly sending data by bleutooth to a raspberry pi. The raspberry pi is accessed by the application on the computer of the general practitioner which sends the data to the LIS. Figure 5.2 shows the same device installed at the general practice.

The laboratory supplies reagents to the general practitioner. These reagents can be used in the POCT device, but also to take samples or perform other medical operations. Only when a general practitioner submits a test sample or printout (either by courier, email or using the service of MobiHealth) the laboratory is able to claim a reimbursement at the health insurer. The reimbursement is a fixed negotiated amount per test (amount depends on the type of test). Because of this, it is very important for the laboratory that performed tests are submitted by the general practitioner.

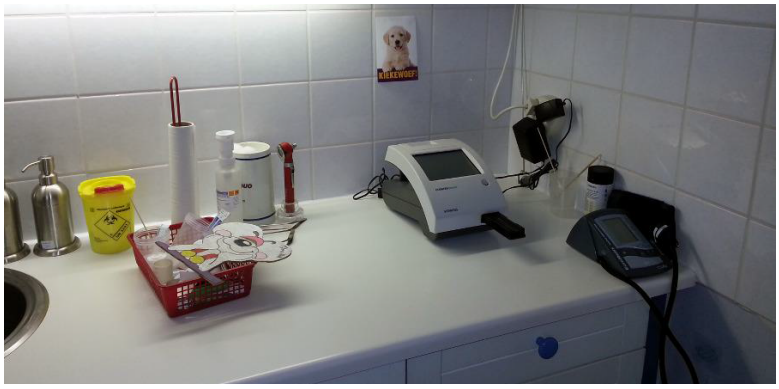

Figure 5.2: POCT device with MobiHealth integration at general practice; obtained from [40]

6. BUSINESS MODEL DEVELOPMENT

To complete Objective 2 in the creation of business models for the MobiHealth case, this chapter will apply BMM α and BMM β to the MobiHealth case (chapter 5). Table 6.1 shows the outline of this chapter. Using BMM α and BMM β three business models will be developed per method. First the "As is"-business model will be developed to reflect the situation without automated processing of POCT by MobiHealth. Secondly the "To be"-business models will be developed. Two "To be"-business models will be developed per method called "To be_1" and "To be_2". Table 6.1 also shows the shortened name of the business models.

The article of Meertens et al. [36] on BMM includes two more steps. In order to develop a business model, the first four are enough. Step five of BMM is called "Design Alternatives". Multiple techniques can be used such as brainstorming and generating scenarios . Also (technical) innovations can be used as input for the design alternatives [36]. In this research the automation of POCT test result processing serves as the technical innovative difference between the "As is" and "To be"-business model.

The "As is" and "To be_1"-business models ought to reflect the same situations using two methods (BMM α and BMM β). Therefore, in order to make this research a bit more interesting, the two "To be_2"-business models will model two different situations. Techniques such as brainstorming will be used to come up with new ideas.

6.1 Solid foundation: role identification & relationship recognition

As the first two steps are largely been done by van Dijk [53] (see Section 1.2), the work of van Dijk will be used as a foundation to build upon in the next section. The reasoning behind the use of the work of van Dijk can be found in Section 3.3. By using the work of van Dijk a solid foundation is guaranteed for business models to be build upon as the same basis is used.

Table 6.1: Outline application business model development

	BMM α	**BMM β**	**Discussed in**
"As is"	$BM_{\alpha}^{\text{As is}}$	$BM_{\beta}^{\text{As is}}$	Section 6.2
"To be_1"	$BM_{\alpha}^{\text{To be}_1}$	$BM_{\beta}^{\text{To be}_1}$	Section 6.3
"To be_2"	$BM_{\alpha}^{\text{To be}_2}$	$BM_{\beta}^{\text{To be}_2}$	Section 6.4 and 6.5

Table 6.2: Identified roles; description roles e^{3}value models

Courier	transports reagents from the laboratory to the general practice and test samples and printouts from the general practice to the laboratory.
General practitioner	works in a general practice; multiple general practitioners can work at a single general practice.
Health insurance company	reimburse general practitioners and laboratories; issue health insurance policies to (potential) patients.
Laboratory	responsible for performing tests on test samples.
Laboratory-HIS integration company	provides one-way integration service between laboratory information system (LIS) and the information system of the general practitioner (HIS).
MobiHealth	provides integration service between POCT device and laboratory.
Patient	person in need of medical attention.
POCT device supplier	manufacturer/seller of POCT devices.

6.1.1 Identify roles

In the first step of BMM α and BMM β roles need to be identified taking part in the business model. The result of this step will be as simple as a list.

The roles identified by van Dijk [53] is an extensive list. Not all roles can be found in the e^{3}value model, but are grouped together. This is done for several reasons, of which the most important one is the fact that groups of roles show a relationship more clearly than the individual roles themselves. Also it simplifies the situation and increase transparency and understanding. The roles listed below ultimately matches the roles in the e^{3}value model. The roles can be found in Table 6.2.

6.1.2 Recognise relationships

The second step of BMM α and BMM β requires to take a closer look at the identified roles (Table 6.2) and determine the relationships among the different roles. To visualise the relationships an e^{3}value model will be used.

From the identified roles, van Dijk has developed two e^{3}value models. Unfortunately a more detailed analysis shows the models of van Dijk [53] are not entirely compliant with the e^{3}value methodology [22]. Therefore new e^{3}value models have created which can be found in Figure 6.1 and Figure 6.3. Compared to the versions of van Dijk the following has changed:

- Better fit with the case study from Section 5.1.
- Matched the roles identified in Section 6.1.1 and Table 6.2 to allow for traceability and transparency.
- Renamed data/message exchanges by value exchanges to comply with the e^{3}value methodology [22].

Prior to these models, but not shown in his paper, two role-relationship matrix are constructed. These role-relationship matrices are reconstructed and can be found in Table A.1 and table A.2. From these matrices the new e^{3}value models are developed. An e^{3}value model is constructed base on Table A.1 depicting the situation without MobiHealth and an e^{3}value model is constructed base on Table A.2 showing the situation with MobiHealth. The first represents the "As is" situation and the second the "To be$_1$" situation. In the role-relationship matrix the relationship described from the right axis to the upper axis. For example in Table A.2 MobiHealth is a service provider to the laboratory.

Figure 6.1 shows the e^{3}value model without MobiHealth. The courier provides a transport service, though this service is used by the general practitioner to transport test samples to the laboratory, the service is of value by the laboratory as the laboratory needs the courier to bring in the test samples. The same can be said for the laboratory integration company. The laboratory integration company allows for test results of the laboratory to flow into the general practitioners information system. This integration is of value by the general practitioner. Even though the laboratory uses the service as well, it is not of value; merely a medium to transport the test results to the general practitioner. The health insurance company have a public interest: "Public health" for which they pay the laboratories and general practitioners. The patients, or rather the all insured, in turn pay the health insurance company to receive an health insurance so their health expenses (made by the general practitioner and laboratory) are covered in case health care is needed.

Figure 6.3 is very similar, but the time consuming courier is replaced by MobiHealth. The upload service of MobiHealth is of value by the laboratories, but used by the general practitioner. General practitioners replace the test processing service of the laboratory by the POCT device provided by MobiHealth. The laboratories still provided the reagents needed by the POCT devices.

Comparing Figure 6.1 and Figure 6.3 shows the value exchanges with and between the health insurance and patient have not changed, therefore a more simplified versions can be made. These are displayed in Figure 6.2 and Figure 6.4. For the development of the business models, the simplified versions will be used.

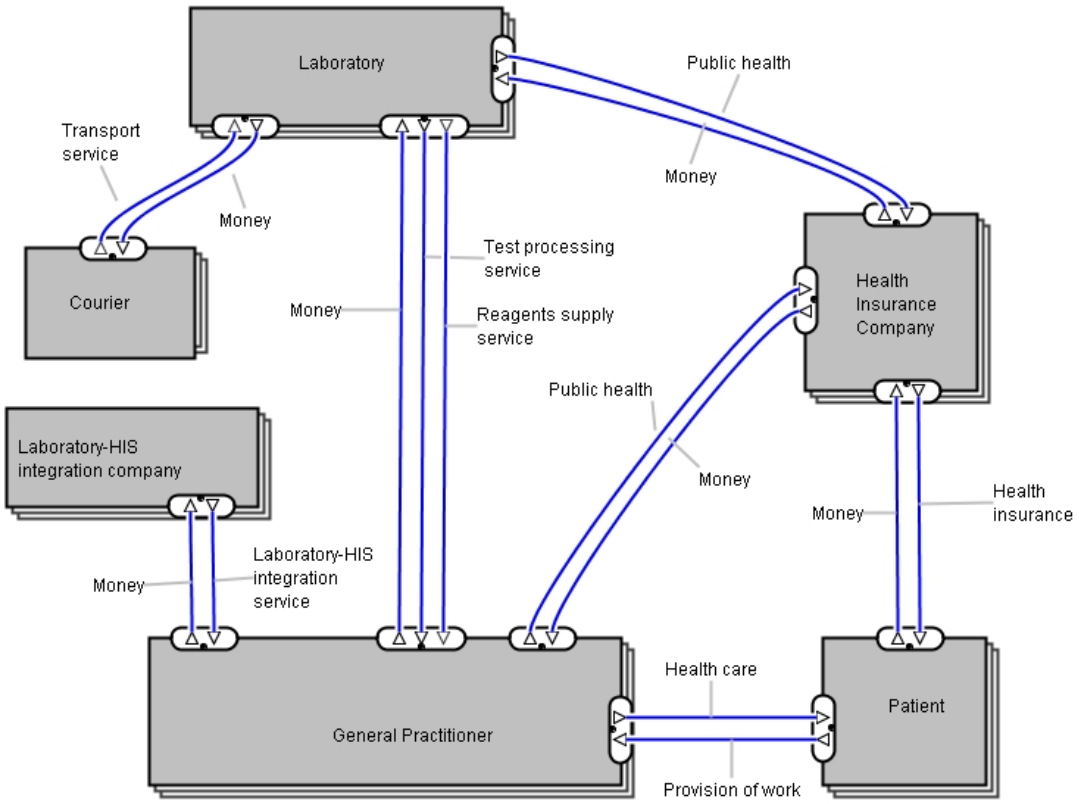

Figure 6.1: e^{3}value model without MobiHealth

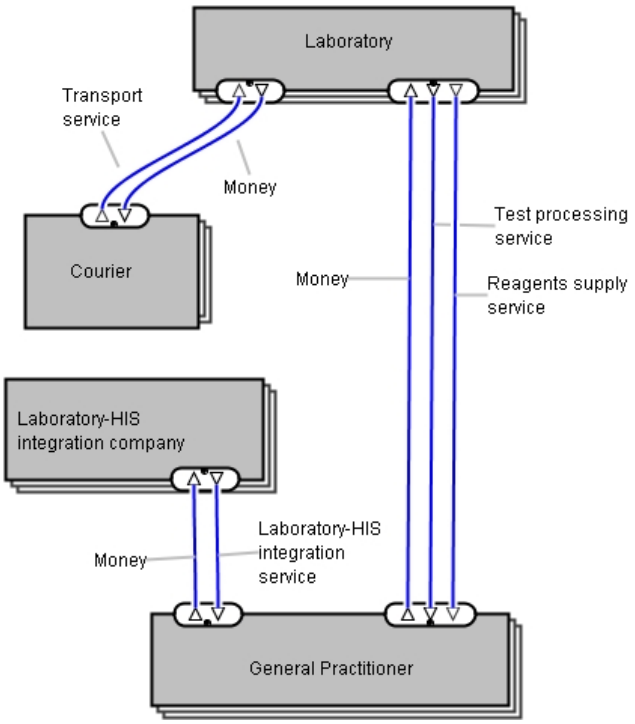

Figure 6.2: Simplified e^3value model of Figure 6.1

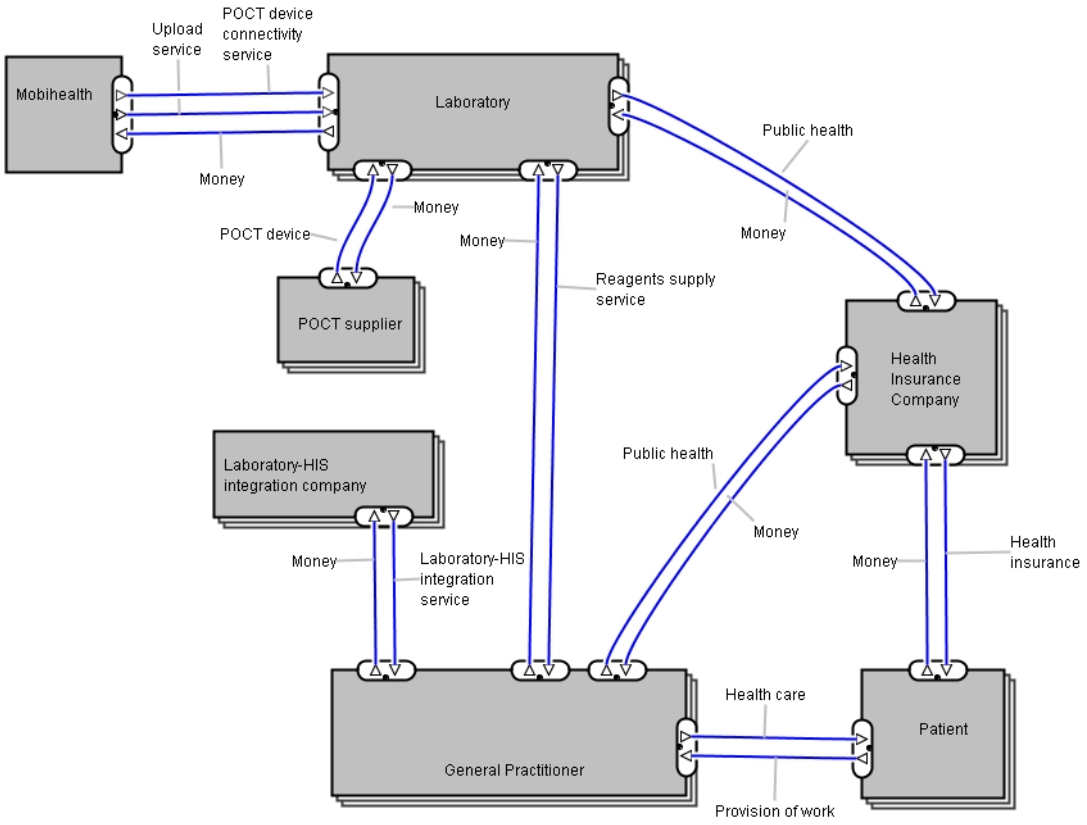

Figure 6.3: e^{3}value model with MobiHealth

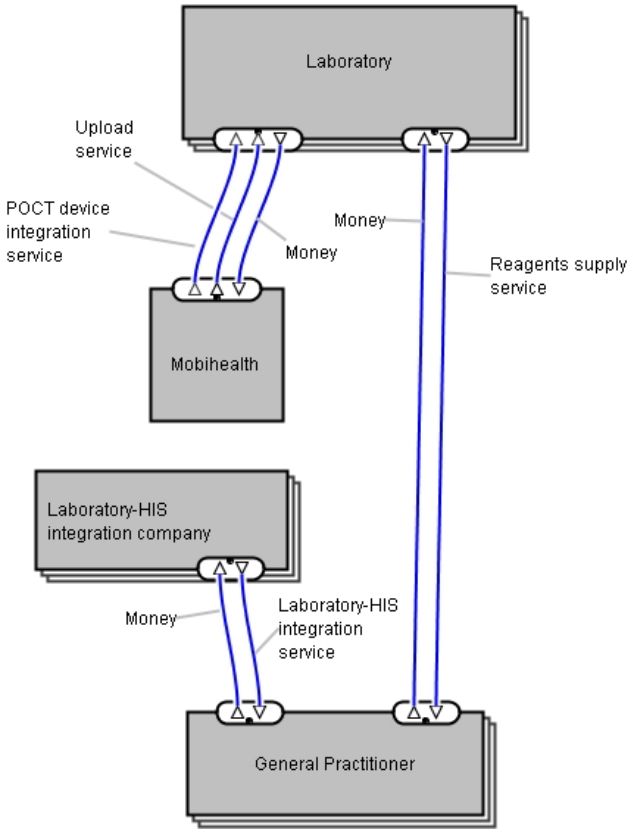

Figure 6.4: Simplified e^{3}value model of Figure 6.3

Table 6.3: Specified activities for the “As is”-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	BPMN [11]	EPC [48]
Reagents supply process	Figure B.1	Figure C.1
Test processing process	Figure B.2	Figure C.2
Transport process	Figure B.3	Figure C.3
Laboratory-HIS integration process	Figure B.4	Figure C.4

6.2 “As is”-business models

This business model uses the identified relations in Table A.1 and the e^3value model in Figure 6.2 and continues by using the methods defined in BMM α and BMM β. From here on, “As is”-Business model α is refereed to as $BM_{\alpha}^{As\ is}$ and “As is”-Business model β is refereed to as $BM_{\beta}^{As\ is}$.

6.2.1 Specify Activities

Four processes are identified from Figure 6.2. The reagents supply process relates the the reagents supply service and the test processing process which relates to the test processing service; both services are provided by the laboratory and are used by the general practitioner. The test processing process uses two other processes: the transport process (related to the transport service provided by the courier) and the laboratory-HIS integration process (related to the laboratory-HIS integration service provided by the laboratory-HIS integration company). The transport process is used by the laboratory to pick up the test samples from the general practitioner. The laboratory-HIS integration process is initialised by the laboratory, but is of value to the general practitioner as this enables test results to flow back into its systems (HIS).

Table 6.3 shows the resulting specified models using the method defined in BMM α and BMM β.

Reagents supply process

The general practitioner checks its stock of reagents, when the general practitioner is low on or out of stock, an order for new reagents is send out to the laboratory. Upon receival of an order for reagents, the laboratory fulfils and ships the order to the general practitioner.

Test processing process

After the general practitioner has performed a test on a patient, the test need to be processed. This is done in the test processing process. The test could have resulted in the acquisition of a sample. In case no test sample is taken, a printout will be made of the results of the test. After some time, the test samples and printouts are taken by courier to be transported to the laboratory. In the laboratory tests will be performed on the test samples and their results will be printed to a printout. All printouts are entered into the laboratory information system (LIS) and

Table 6.4: Costs for the “As is”-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	Time-driven ABC [28]	Variable costing [19]
Reagents supply process	€ 0,-	€ 0,-
Test processing process	€ 2,- / test	€ 2,- / test
Transport process	N/A	N/A
Laboratory-HIS integration process	€ 15,- / month / general practice	€ 15,- / month / general practice

double checked by a second pair of eyes. When the printout is correctly entered into the LIS, the results need to be send back to the general practitioner. This is done by the laboratory-HIS integration.

Transport & laboratory-HIS integration process

The process is normally initialised by contract. The laboratory and general practitioner beforehand negotiate how frequent the courier will come and pick up test samples and printouts. In case a general practitioner has an exceptional busy day or week (i.e. a higher production/more patients), the process can be started by the general practitioner to let the courier pick up the test samples and printouts earlier. The same logic is followed in the laboratory-HIS integration process. Depending on the contract between the general practitioner and the laboratory-HIS integration company, test results are pulled from the LIS into the HIS when either a new entry is made in the LIS or by batch at specified times.

6.2.2 Quantify Model

The specified activities in the previous step will be used to determine the costs using the method defined in BMM α and BMM β. Table 6.4 shows the results from this quantification step. Bellow more details can be found on how costs have been determined.

Reagents supply process

As described in the case study (Section 5.1) the laboratory sends the reagents for free to the general practitioner, therefore costs for the general practitioner are € 0,00. However the laboratory does make costs for the reagents, but these are covered by the health insurer and so fall outside the scope of the e^3value model of Figure 6.2.

Test processing process

The test processing process has two roles who will make costs due to the process. The costs made by the transport process will be discussed later. The costs made by the laboratory due to this process can be split in two: labour costs and material costs. Depending on whether

it is a test sample or test printout; a test needs to be performed on the test sample. Since there are a lot of different tests that can be performed, the costs of these activities can not easily be assessed. Though it is evident that tests do require time and resources and laboratory equipment has a limited capacity. The cost made by this equipment can be considered material costs. The administration of test results in the LIS and the activity of a second person to check this are labour costs.

Using the Time-driven ABC [28] method (BMM α) : interviews reveal these activities take about 5 minutes total. With a € 25,- hourly rate are the labour costs estimated to be about € 2,- per test to be processed. As argued the material costs (use of test equipment) is not estimated.

Using the Variable costing [19] method (BMM β): both the labour costs and the material costs are variable costs (i.e. costs rise as more tests are performed). The method differ in the way overhead costs are treated. Since no overhead is visible in the process, these costs can not be determined. The costs are therefore the same as determined using the time-driven ABC [28] method.

Transport process

The transport process shown in Figure B.2 is invoked at least once a day. The cost made during this process are mainly made by the courier which will be reflected in the invoice send to the laboratory. But also the time required to hand over the test printouts and sample to the courier and from the courier to the laboratory needs to be considered. Overall the courier can be seen as a service provider who makes costs per kilometre. In some cases the courier is part of the laboratory instead of a separate party.

Laboratory-HIS integration process

The laboratory-HIS integration process shown in Figure B.4 is also made possible by a service provider. Companies providing a laboratory-HIS integration mostly work with monthly fees. Zorgmail [61] for example, starts from € 15,- per month per general practice. These costs are considered non-manufacturing costs for the general practitioner. Figure 3.4 shows non-manufacturing costs are directly affecting the profit and loss account by both methods (absorption and variable costing).

6.2.3 Quantify Model II

The specified activities as well as the costs in the previous two step will be used to determine the price using the method defined in BMM α and BMM β. Table 6.5 shows the results of this second quantification step. More details can be found bellow on how prices have been determined.

Reagents supply process & Test processing process

The laboratory is not able to set a price for the reagents send to the general practitioner and the processing of test. These prices are set by the health insurance companies and fall outside

Table 6.5: Revenue for the “As is”-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	Cost-plus pricing [19]	Value-based pricing [7]
Reagents supply process	N/A	N/A
Test processing process	N/A	N/A
Transport process	N/A	N/A
Laboratory-HIS integration process	€ 15,- / month / general practice	€ 15,- / month / general practice

Table 6.6: Model modelling for the “As is”-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	BMO [41]	BM Concept [26]
Model	Figure D.1	Figure D.4

the scope of the e^{3}value model of Figure 6.2. Therefore the reagents supply process will not be included as this is outside our power and scope.

Transport process

The price for the transport process is set by the courier and is largely dependant on the distance between the laboratory and the general practices on its route. As the costs of this process are unable to be determined within this research, we are unable to set a price.

Laboratory-HIS integration process

The laboratory-HIS integration company bills the general practice for its service, the costs made by the general practice for this service is equal to the price set by the laboratory-HIS integration company.

6.2.4 Model Modelling

For the final step, set out in Section 4.2, the business model will be modelled. Table 4.3 and Table 4.4 will be of help during the development of these models as it shows how all previous steps prepare for this final step.

As shown in Table 6.6, Figure D.1 shows the resulting model of $BM_{\beta}^{As\ is}$ in the form a Business Model Canvas. A Business Model Canvas can be used to visualise a BMO model [42]. Figure D.4 shows the business model as conceptualised with BM Concept [26]. Both models (Figure D.1 and Figure D.4) takes the perspective of the laboratory.

Table 6.7: Specified activities for the "To be$_1$"-business models

	$BM_{\alpha}^{To\ be_1}$	$BM_{\beta}^{To\ be_1}$
Method	BPMN [11]	EPC [48]
Reagents supply process	Figure B.1	Figure C.1
POCT device integration process	Figure B.5	Figure C.5
Test upload process	Figure B.6	Figure C.6
Laboratory-HIS integration process	Figure B.4	Figure C.4

6.3 "To be$_1$"-business models

This business model uses the identified relations in Table A.2 and the e^{3}value model in Figure 6.4 and continues by using the methods defined in BMM α and BMM β. From here on, "To be$_1$"-Business model α is refereed to as $BM_{\alpha}^{To\ be_1}$ and "To be$_1$"-Business model β is refereed to as $BM_{\beta}^{To\ be_1}$.

6.3.1 Specify Activities

Four processes are identified from Figure 6.4. The reagents supply process is exactly the same as described in Section 6.2. The POCT device integration process is initialised by the general practitioner and replaces the test processing service of the laboratory as the POCT device will take care of the testing. The POCT device integration process relates to the POCT device integration service in the e^{3}value model (Figure 6.4). Tests performed with the POCT devices are uploaded to the laboratory by the test upload service of MobiHealth. Using the existing laboratory-HIS integration, the results are pulled form the LIS to the HIS by the laboratory-HIS integration process.

Table 6.7 shows the resulting specified models using the method defined in BMM α and BMM β.

POCT device integration process

The POCT device integration process is very similar to a typical ordering process. The process starts by the general practitioner recognising the need for a (new) POCT device. This need is translated into an order and placed at the laboratory. which places the order at its supplier. The general practitioner not only needs a POCT device, but also needs it to process the results automatically. MobiHealth therefore integrates the POCT device with its systems to be able to support the test upload service of MobiHealth. The test upload service is facilitated by the test upload process.

Test upload process

The test upload process first uploads the test results of the POCT device to MobiHealth. Every once in a while the laboratory checks for new uploads and pulls them into the laboratory information system (LIS). This entirely eliminates the need for a courier, but mainly speeds up the

Table 6.8: Costs for the "To be$_1$"-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	Time-driven ABC [28]	Variable costing [19]
Reagents supply process	See Table 6.4	See Table 6.4
POCT device integration process		
Administration	€ 6,25 / POCT device *	€ 6,25 / POCT device *
Integration	€ 50,- / POCT device **	€ 50,- / POCT device **
Hardware	€ 100,- / POCT device **	€ 100,- / POCT device **
Test upload process	N/A	€ N/A
Laboratory-HIS integration process	See Table 6.4	See Table 6.4

* cost made by the laboratory
** cost made by MobiHealth

process by eliminating the need for physical transportation of the test results and test samples (tests are performed by the POCT device instead of in the laboratory). Moreover test results are send immediately after the test has been performed instead of send by courier in bulk. From there the existing laboratory-HIS integration takes over to ensure the test results are stored in the system of the general practitioner (HIS).

6.3.2 Quantify Model

The specified activities in the previous step will be used to determine the costs using the method defined in BMM α and BMM β. Table 6.8 shows the results from this quantification step. Bellow more details can be found on the cost determination.

POCT device integration process

The POCT device integration process takes between two days to several weeks to complete. This is mainly due to the fact that the installation of POCT devices is done by the laboratory and is subject to their calendar. It is possible to install multiple POCT devices at once. These costs are considered labour costs. The costs for the POCT device itself and the hardware needed by MobiHealth are material costs. The costs for a POCT device depends on the type of POCT device and will therefore not be incorporated.

Using the Time-driven ABC [28] method (BMM α): interviews reveal the installation of the POCT device by the laboratory is done in 15 minutes. MobiHealth needs an hour with two persons to connect the POCT device to their systems. With the € 25,- an hour assumption will it cost € 6,25 for the laboratory (administration) and € 50,- for MobiHealth (integration). The hardware costs for MobiHealth are € 100,- for a Raspberry Pi, Firefly and bluetooth dongle (hardware).

Using the Variable costing [19] method BMM β): both the labour costs and the material costs are variable costs (i.e. costs rise as more tests are performed). The method differ in the way overhead costs are treated. Since no overhead is visible in the process, these costs can not be determined. The costs are therefore the same as determined using the time-driven ABC [28] method.

Table 6.9: Revenue for the "To be$_1$"-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	Cost-plus pricing [19]	Value-based pricing [7]
Reagents supply process	See Table 6.5	See Table 6.5
POCT device integration process	€ 100,- profit margin	€ 0,-
Test upload process	€ 0,30 / upload	€ 1,- / upload
Laboratory-HIS integration process	See Table 6.5	See Table 6.5

Test upload process

The test upload process is completely automated, the costs for this process need to be looked for in terms of supportive resources such as hardware, infrastructure and software. The process itself therefore does not produce costs for MobiHealth, but does produce costs for laboratory as it uses the service of MobiHealth. The test upload process uses the laboratory-HIS integration process which, as discussed in Section 6.2, produces costs.

6.3.3 Quantify Model II

The specified activities as well as the costs in the previous two step will be used to determine the price using the method defined in BMM α and BMM β. Table 6.9 shows the results of this second quantification step. More details can be found bellow on the price determination.

POCT device integration process

MobiHealth sends the laboratory an invoice for the integration of POCT devices with their systems, the costs for the integration includes time and hardware. From the previous step this is estimated to be € 150,00 per POCT device.

Using the Cost-plus pricing [19] method (BMM α): interviews reveal Interviews with MobiHealth reveal they use a € 100,- profit margin. Te method states one can use a percentage or a fixed amount for profit, MobiHealth has chosen for the last one to determine their price.

Using the Value-based pricing [7] method (BMM β): the POCT device integration process allows MobiHealth to ensure future revenue by hooking the general practitioners up to their systems. Therefore this process is mainly of value by MobiHealth itself. To persuade the laboratory to integrate their POCT devices with MobiHealth technology, MobiHealth should pay for the costs made by the POCT device integration process.

Test upload process

In the test upload process MobiHealth sends the laboratory an invoice per upload for their services. In the previous step the argumentation is made that the costs for this services are difficult to estimate or allocate for this process.

Table 6.10: Model modelling for the "To be$_1$"-business models

	$BM_{\alpha}^{As\ is}$	$BM_{\beta}^{As\ is}$
Method	BMO [41]	BM Concept [26]
Model	Figure D.2	Figure D.5

Using the Cost-plus pricing [19] method (BMM α): interviews reveal MobiHealth uses a fixed profit margin. When costs are zero or close to zero and a profit margin of 30 cents is used per upload, this results in € 0,- + € 0,30 = € 0,30 per upload.

Using the Value-based pricing [7] method (BMM β): this is a high value service for MobiHealth and for the laboratory as this enables the POCT test results to flow to the laboratory. MobiHealth can therefore ask € 1,- per upload. MobiHealth can decide to give discount above a certain amount of uploads, but this will not be covered in this research.

6.3.4 Model Modelling

For the final step, set out in Section 4.2, the business model will be modelled. Table 4.3 and Table 4.4 will be of help during the development of these models as it shows how all previous steps prepare for this final step.

As shown in Table 6.10, Figure D.1 shows the resulting model of $BM_{\beta}^{As\ is}$ in the form a Business Model Canvas. A Business Model Canvas can be used to visualise a BMO model [42]. Figure D.4 shows the business model as conceptualised with BM Concept [26]. Both models (Figure D.1 and Figure D.4) takes the perspective of the MobiHealth.

Table 6.11: Specified activities for $BM_{\alpha}^{To\ be_2}$

Method	BPMN [11]
Reagents supply process	Figure B.1
POCT device integration process	Figure B.5
Synchronisation process	Figure B.7

6.4 "To be$_2$"-Business model α

So far the case study in Section 5.1 has been used for the construction of the business models. The "To be"-Business models aim to develop more alternatives. The development of "To be$_2$"-Business model α will not use the earlier developed role-relationship matrices and e^{3}value models. All stakeholders and relationships have been reviewed. New relationship have been formed by means of a brainstorm session. From here on, this business model ("To be$_2$"-Business model α) is refereed to as $BM_{\alpha}^{To\ be_2}$.

6.4.1 Recognise relationships

The new role-relationship matrix can be found in Table A.3. Again a e^{3}value model is created based on this role-relationship matrix which can be found in Figure 6.5. A simplified version of this model can be found in Figure 6.6.

In the new situation the time-consuming transport process of the courier has been eliminated by placing POCT devices at the general practice. Also POCT test results are digitally send to the laboratory. This service is facilitated by MobiHealth. The laboratory-HIS integration company has also been eliminated from the scene and activities have also been taken over by MobiHealth. In this case, the general practitioner does not need to wait for the laboratory to initiate the laboratory-HIS integration process.

6.4.2 Specify Activities

To specify the activities, BPMN [11] is used. Three processes are identified from Figure 6.4. The reagents supply process, shown in Figure B.1, is exactly the same as described in Section 6.2; the POCT device integration process, depicted in Figure B.5, is exactly the same as described in Section 6.3. The test upload process and laboratory-HIS integration process has been changed compared to the ones described in Section 6.2 and Section 6.3 as MobiHealth will take care of the laboratory-HIS integration. This new process is called the synchronisation process. Table 6.11 provides an overview of the specified activities.

Synchronisation process

The synchronisation process can be found in Figure B.7. The process depicted in Figure B.6 shows the laboratory initiating the laboratory-HIS integration process when a test result is pulled into the LIS from MobiHealth. In the new situation MobiHealth takes over this process, so the integration (i.e. the transfer of test results form the LIS to HIS) is now performed by MobiHealth

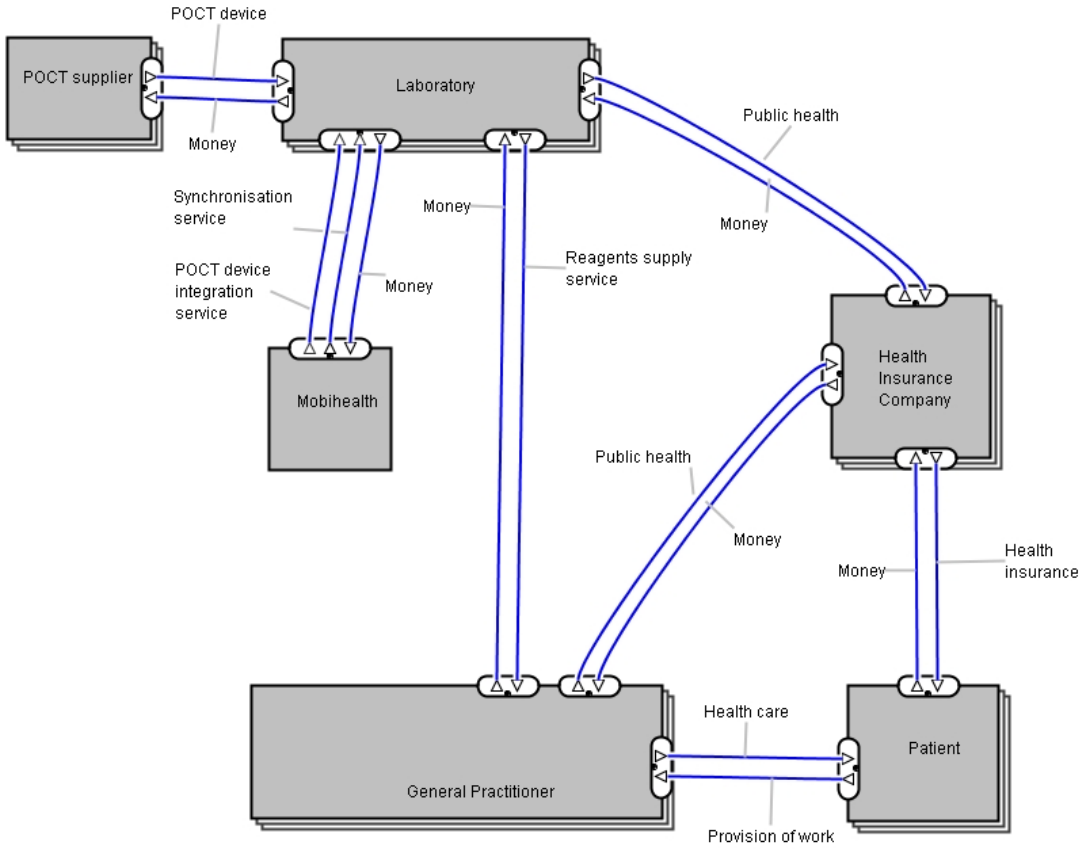

Figure 6.5: e^{3}value model for MobiHealth taking over LIS-HIS integration

instead of a third party (i.e. the laboratory-HIS integration company). By moving the laboratory-HIS integration service from the laboratory-HIS integration company (i.e. MobiHealth offering an additional service) the need for the laboratory-HIS integration company is eliminated.

6.4.3 Quantify Model

For the first quantification Time-driven ABC [28] will be used. The processes described in the previous step are depicted in Figures B.1, B.5 and B.7 and will be used for this quantification. The quantification of the reagents supply process (Figure B.1) is already discussed in Section 6.2. The quantification of the POCT device integration process (Figure B.5) is already discussed in Section 6.3. Leaving only to quantify the synchronisation process depicted in Figure B.7.

Table 6.12 shows the results from this quantification step. Bellow more details can be found on the cost determination.

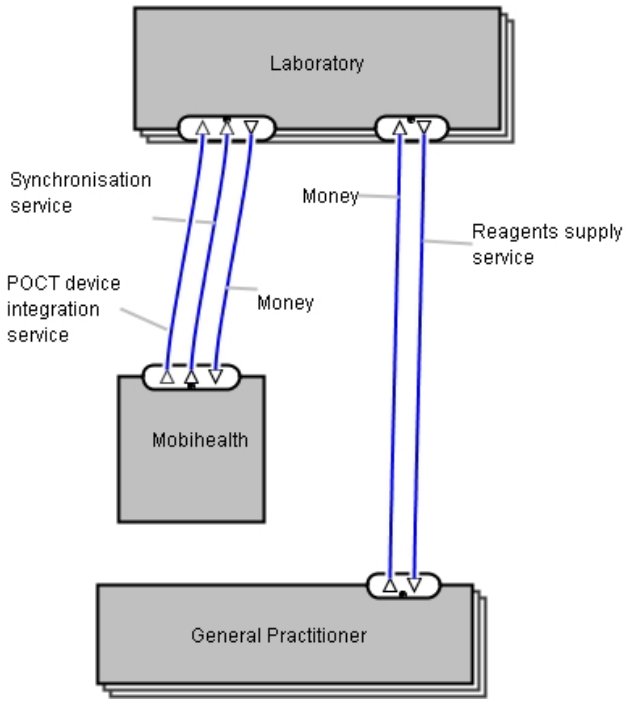

Figure 6.6: Simplified e^{3}value model of Figure 6.5

Table 6.12: Costs for the $BM_{\alpha}^{\text{To be}_2}$

Method	Time-driven ABC [28]
Reagents supply process	See Table 6.4
POCT device integration process	See Table 6.8
Synchronisation process	N/A

Synchronisation process

The costs of the synchronisation process depicted in Figure B.6 have been reduced by removing the laboratory-HIS integration process shown in Figure B.4. The synchronisation process (Figure B.7) does not produce costs for MobiHealth, but does produce costs for the laboratory for using the service of MobiHealth (will be discussed in the next step).

6.4.4 Quantify Model II

To set the prices, the cost-plus pricing [19] method will be used. In the previous step it is determined that the costs of the synchronisation process shown in Figure B.6 has been reduced. As Figure 6.5 shows all costs made by the laboratory and general practitioner related to public health are covered by the health insurance companies, the cost reduction ultimately is beneficial to the health insurance companies. This leaves room for MobiHealth to increase their profit margin.

Table 6.13: Revenue for $BM_{\alpha}^{To\ be_2}$

Method	Cost-plus pricing [19]
Reagents supply process	See Table 6.5
POCT device integration process	See Table 6.9
Synchronisation process	€ 0,60 / upload

Table 6.13 shows the results of this second quantification step. More details can be found bellow on the price determination.

Synchronisation process

In Section 6.3 the profit margin for the test upload process (Figure B.6) is set to 30 cents per upload. By consuming the laboratory-HIS integration process the profit margin can increase to 60 cents per upload. Using the cost-plus pricing method this results to 0,00 Euro + 0,60 Euro = 0,60 Euro per upload.

6.4.5 Model Modelling

For the final step of BMM α, set out in Section 4.2, BMO [41] will be used to model the business model. Table 4.3 will be of help during the development of the model as it shows how all previous steps prepare for this final step.

Figure D.3 shows the resulting model in the form a Business Model Canvas. A Business Model Canvas can be used to visualise a BMO model [42]. The model takes the perspective of Mobi-Health.

Table 6.14: Specified activities for $BM_{\beta}^{To\ be_2}$

Method	EPC [48]
Reagents supply process	Figure C.1
POCT deployment process	Figure C.7
Synchronisation process	Figure C.8

6.5 "To be$_2$"-Business model β

So far the case study in Section 5.1 has been used for the construction of the business models. The "To be"-Business models aim to develop more alternatives. The development of "To be$_2$"-Business model β will not use the earlier developed role-relationship matrices and e^{3}value models. All stakeholders and relationships have been reviewed. New relationship have been formed by means of a brainstorm session. From here on, this business model is refereed to as BM2BC.

6.5.1 Recognise relationships

The new role-relationship matrix can be found in Table A.4. Again a e^{3}value model is created based on this role-relationship matrix which can be found in Figure 6.7. A simplified version of this model can be found in Figure 6.8.

In the new situation the laboratory-HIS integration company has been eliminated from the scene and activities have been taken over by MobiHealth as well as the supply of POCT devices. In this case, the general practitioner does not need to wait for the laboratory to initiate the laboratory-HIS integration process. Also MobiHealth does not have to wait for the laboratory to place POCT device at the general practitioner to be able to integrate it with its systems.

6.5.2 Specify Activities

To specify the activities, EPC [48] is used. Three processes are identified from Figure 6.8. The reagents supply process, shown in Figure C.1, is exactly the same as described in Section 6.2. The two new processes are called the POCT deployment process and the synchronisation process. These processes allow MobiHealth to supply the general practitioner with POCT devices. Table 6.14 provides an overview of the specified activities.

POCT deployment process

The POCT deployment process is can be found in Figure C.7. The process is very similar to the POCT device integration process shown in Figure C.5. In the POCT deployment process MobiHealth is not dependent on the laboratory to place a POCT device at the general practitioner. MobiHealth will take care of supplying the POCT devices. The general practitioner requests a POCT device at the laboratory, the laboratory forwards this request to MobiHealth to supply a fully integrated POCT device.

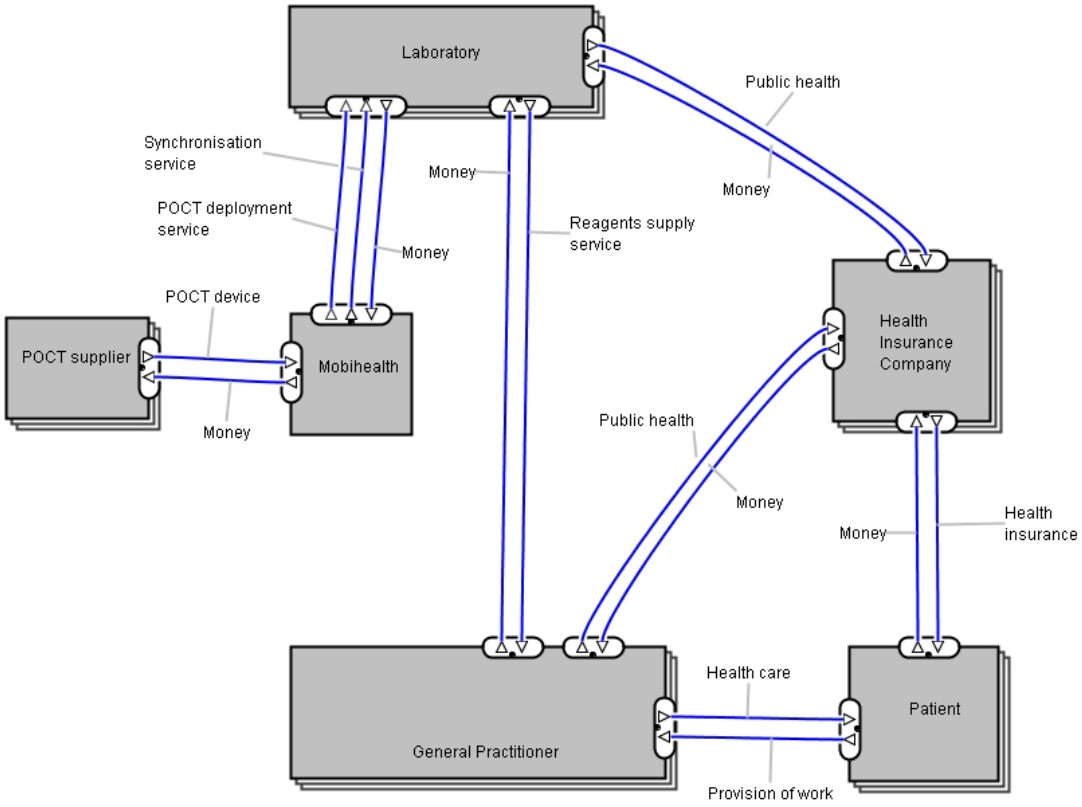

Figure 6.7: e^{3}value model for MobiHealth providing integrated service

Synchronisation process

The synchronisation process can be found in Figure C.8. The process depicted in Figure C.6 shows the laboratory initiating the laboratory-HIS integration process when a test result is pulled into the LIS from MobiHealth. In the new situation MobiHealth takes over this process, so the integration (i.e. the transfer of test results form the LIS to HIS) is now performed by MobiHealth instead of a third party (i.e. the laboratory-HIS integration company). By moving the laboratory-HIS integration service from the laboratory-HIS integration company (i.e. MobiHealth offering an additional service) the need for the laboratory-HIS integration company is eliminated.

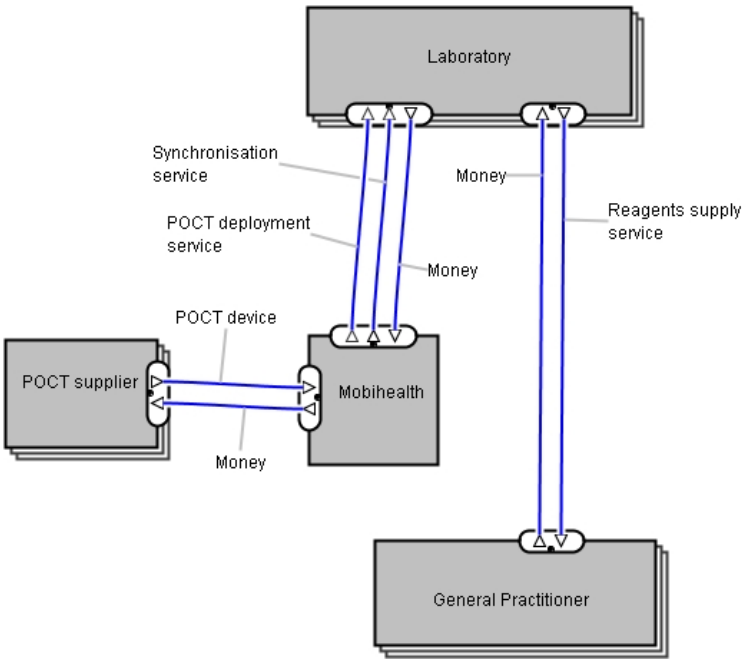

Figure 6.8: Simplified e^{3}value model of Figure 6.7

Table 6.15: Costs for the $BM_{\beta}^{To\ be_2}$

Method		Variable costing [19]
Reagents supply process		See Table 6.4
POCT deployment process		
	Integration	€ 50,- / POCT device
	Hardware	€ 100,- / POCT device
Synchronisation process		N/A

6.5.3 Quantify Model

For the first quantification Variable costing [19] will be used. The processes described in the previous step are depicted in Figures C.1, C.7 and C.8; and will be used for the quantification. The quantification of the reagents supply process (Figure C.1) is already discussed in Section 6.2. Leaving only to quantify the POCT deployment process and synchronisation process in Figures C.7 and C.8.

Table 6.15 shows the results from this quantification step. Bellow more details can be found on the cost determination.

POCT deployment process

The quantification of the POCT deployment process is similar to the POCT device integration process (Figure C.5) as discussed in Section 6.3. However, the new process eliminates the

Table 6.16: Revenue for $BM_{\beta}^{To\ be_2}$

Method	Cost-plus pricing [19]
Reagents supply process	See Table 6.5
POCT deployment process	€ 100,- / year / general practice
Synchronisation process	€ 600,- / year / general practice

need for the laboratory to invest time and resources to place the POCT device at the general practitioner. Concluding from the quantification in Section 6.3 the costs for MobiHealth are € 50,- for the installation of the POCT device and € 100,- for the hardware.

Synchronisation process

The costs of the synchronisation process depicted in Figure B.6 have been reduced by removing the laboratory-HIS integration process shown in Figure B.4. The synchronisation process (Figure C.8) does not produce costs for MobiHealth, but does produce costs for the laboratory for using the service of MobiHealth.

6.5.4 Quantify Model II

For the second quantification and to set a price the Value-based pricing [7] method will be used. Table 6.16 shows the results of this second quantification step. More details can be found bellow on the price determination.

POCT deployment process

MobiHealth makes costs for the purchasing or rent of the POCT device. These costs are not easily quantifiable as different POCT devices have different price tags. The costs are credited to the laboratory. MobiHealth can make a decision based on the added value of the service to determine whether or not to add a fee. Though this is a value-based decision, the result is cost-plus priced service. In this quantification the added value is determined to be € 100,- per year per general practice as the process also frees the laboratory from spending time and resources to place POCT devices at general practitioners

Synchronisation process

Unlike the upload service in Section 6.3 where the price is set per upload, the synchronisation process facilitates the synchronisation service. By valuing the service instead of the uploaded test, MobiHealth can credit € 600,- per general practice per year to the laboratory.

Table 6.17: Results business model development

	BMM α			BMM β
	Result	**Elaboration**		**Result**
"As is"	Figure D.1	Section 6.2		Figure D.4
"To be$_1$"	Figure D.2	Section 6.3		Figure D.5
"To be$_2$"	Figure D.3	Section 6.4	Section 6.5	Figure D.6

6.5.5 Model Modelling

For the final step of BMM β, set out in Section 4.2, BM Concept [26] will be used to model the business model. Table 4.3 will be of help during the development of the model as it shows how all previous steps prepare for this final step. The result can be found in Figure D.6. The model takes the perspective of MobiHealth.

6.6 Conclusion

The creation of business models by using BMM α and BMM β on the MobiHealth case (Objective 2) is completed. As shown in Table 6.1 for both BMM derivatives three business models have been constructed. The "As is"-business models reflect the situation without automated processing of POCT by MobiHealth. In the "To be"-business models MobiHealth takes part and performs offers different services.

The "As is" and "To be$_1$"-business models ought to reflect the same situations using two methods (BMM α and BMM β). Therefore, in order to make this research a bit more interesting, the two "To be$_2$"-business models has modelled two different situations. The hope is that this will have an impact on the business cases developed in the next chapter.

As it turned out in Section 6.1.2 the work of van Dijk [53] was not entirely compliant with the e^{3}value [22]. This has been fixed to provide a solid foundation to work upon in the "As is" and "To be$_1$"-business models. The resulting business models can be found in Table 6.17

7. Business case development

This chapter will create business cases based on the business models developed in Chapter 6. Objective 3 aims to develop business cases by applying the Business Case method for Business Models and a sensitivity analysis methods. By doing so, this chapter will complete Objective 3 by using the resulting business models from Objective 2. In order to achieve Objective 3 two research sub-questions need to be answered. Firstly what is the Business Case method for Business Models and secondly what sensitivity analyses method is suitable for business cases?

The Business Case method for Business Models (BM2BC method) is not an extension of BMM, but rather a method which can be used after BMM to further quantify and compare business models [37]. This will be discussed in more detail in Section 7.1.

The business models will also be subject to a sensitivity analyses. Saltelli et al. [47] define a sensitivity analysis as "the study of how the uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs". The quantitative part of a business case is a mathematical model, therefore we are able to apply a sensitivity analysis on it. This will be discussed in more detail in Section 7.1.1.

7.1 Business Case method for Business Models

As discussed in chapter 6, in the article on BMM two more steps included [36]. The first suggested additional step to BMM ("Design Alternatives") has been done in chapter 6. The second and last suggested additional step to BMM is called "Analyse Alternatives". A possible implementation is given in an other paper by Meertens et al. [37].

A lot of research has been done in business case development. Vienneau and Nicholls [56] provide a practical guide to develop and maintain a business case. Ward et al. [58] focusses specifically on IT investments, which is continued by the work of Peppard et al. [44]. Some well known methodologies, such as PRINCE2 [6] also provide a method for developing business cases. The Business Case method for Business Models (BM2BC method) is based on the work of Ward et al. [58], but is tailored to the development of a business case based on business models.

All mentioned business case methods aim to cover the effects, risks and costs of multiple business changes to support decision making. BM2BC is chosen, because it specifically focusses on business models. BM2BC consists of eight components which need to be addressed in the business case [37]:

Business driver The cause, problem, or opportunity that needs to be addressed

Business objectives The goal of the business case stating which objectives are aimed for

Alternatives Representing the options to reach the objectives

Effects Positive and negative effects that come with the pursued alternative

Risks Risks that come with the pursued alternative

Costs Costs that come with the pursued alternative

Alternative selection Based on gathered data the best alternative is chosen

Implementation plan Plan which explains when and how the alternative is implemented

The last two components will not be included in the business cases developed in Section 7.3 and 7.4. Though enough information has been gathered to perform the alternative selection and outline an implementation plan, these components are outside the scope of this research.

7.1.1 Sensitivity analysis

The cost component in the business model can be considered a mathematical model. Therefore it is suitable to apply a sensitivity analysis upon the cost component. Saltelli et al. [47] define a sensitivity analysis as "the study of how the uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs". Most sensitivity analysis methods involve changing one or more parameters to study their influence on the outcome of the model [25, 43, 47].

Since the number or POCT tests performed and the number of POCT devices per general practice (multiple general practitioners can work in the same practice) determines the outcome, different scenarios have been constructed. The scenarios are based on the case study (Section 5.1 and interviews.

Scenario 1 In this scenario 720 POCT tests are taken per year (60 per month) using 2 POCT device in a single general practice.

Scenario 2 In this scenario 960 POCT tests are taken per year (80 per month) using 3 POCT device in a single general practice.

Scenario 3 In this scenario 1200 POCT tests are taken per year (100 per month) using 3 POCT device in a single general practice.

7.2 Introduction business cases

To start the business case, the first three components of BM2BC (Business driver, Business objectives and Alternatives) will be addressed. The components Effects, Risks and Costs will be introduced as well. Business case α (BC_α; Section 7.3) will cover the business models developed using BMM α, whereas Business case β (BC_β; Section 7.4) will cover the business models developed using BMM β. This can also be seen in Table 7.1.

7.2.1 Business driver

In the Netherlands, and other developed countries, healthcare and welfare costs are rising. Solutions need to be found to keep these costs within reasonable limits [12, 13, 16, 30], but without any loss of healthcare quality [15].

Table 7.1: Business case options

	Business case α	**Business case β**
Alternative 1	$BM_{\alpha}^{\text{As is}}$ (Section 6.2)	$BM_{\beta}^{\text{As is}}$ (Section 6.2)
Alternative 2	$BM_{\alpha}^{\text{To be}_1}$ (Section 6.3)	$BM_{\beta}^{\text{To be}_1}$ (Section 6.3)
Alternative 3	$BM_{\alpha}^{\text{To be}_2}$ (Section 6.4)	$BM_{\beta}^{\text{To be}_2}$ (Section 6.5)
	Section 7.3	**Section 7.4**

Point-Of-Care Testing (POCT) can be part of the solution. The goal of POCT is to provide accurate, reliable, fast and cost-effective information about patient condition [50]. Altieri and Camarca [5] predict POCTwill likely become the standard of care in the near future, but state that successful implementation will depend on cooperation between the central laboratory, information systems, and operator personnel. According to Luppa et al. [35] POCT shortens the time to clinical decision-making about additional testing or therapy, as delays are no longer caused by transport and preparation of clinical samples, and biochemical-test results are rapidly available at the point of care. Luppa et al. [35] and Hale and Kost [24] suggest improved medical outcome and lower costs maybe ensured by POCT

7.2.2 Business objectives

In accordance with the business drivers, the pursued objectives are the following:

Business Objective 1 No loss of healthcare quality

Business Objective 2 Reduce costs of healthcare

Business Objective 3 Reduce time to clinical decision-making

7.2.3 Alternatives

The options will be the business models developed in chapter 6. Two business cases will be developed, Business case α (BC_{α}) using the business models developed with BMM α and Business case β (BC_{β}) developed using the result of BMM β. Table 7.1 is similar to Table 6.1, but shows the developed business models function as options for the BM2BC method. The resulting business cases can be found in Section 7.3 and 7.4.

7.2.4 Effects

For each business case this section discusses the positive and negative effects (also known as benefits and dis-benefits). Effects are indicated to be positive or negative. Every effect has an owner, meaning the role affected by the effect. The effect is categorised in one of three groups the degree of business change. The effect can be the result of doing something new, something better or stop doing something. To quantify the effect a degree is assigned to indicate the ability to assign a value to the effect as well as a means of measurement. Financial explicitness indicates a financial value can be calculated by applying financial formula (e.g. cost, price). Effects

categorised as quantifiable means sufficient evidence exist to forecast how much improvement should result from the changes. With a measurable effect some aspect of performance is measured, but it is not possible to estimate how much performance will improve when changes are implemented. Lastly observable effects rely on agreed upon criteria or judgement to decide to what extent the benefit will be realized [58].

7.2.5 Risks

For each business case this section discusses the risks involved for each option. For each risk several components will be identified. An event is something that could happen. The owner is the role to whom the event happens, thought others may be affected by it. The probability is the likelihood of the event to happen. The impact indicates how bad it will be if it happens. For example the probability of the building catching on fire is low, but the impact is high since the entire building is out of business. A response to a risk can be split in two categories: mitigation and contingency. Mitigation aims to reduce the probability and contingency aims to reduce the impact.

7.2.6 Costs

For each business case this section discusses the costs and benefits for every role. The numbers are based on the quantitative steps of the business models. The cashflows are given per role over a period of 5 years. Within this section the sensitivity analysis will be performed as discussed in Section 7.1.1.

7.3 Business case α

Business case α (BC_α) compares the business models developed using BMM α as set out in Section 7.2.3. This comparison will be done on three dimensions: effects, risks and costs.

7.3.1 Effects

The effects of BC_α are structured as described in Section 7.2.4. Table 7.2 and 7.3 show the effects of $BM_\alpha^{\text{To be}_1}$ and $BM_\alpha^{\text{To be}_2}$ compared to $BM_\alpha^{\text{As is}}$. This shows the positive and negative effects of the "To be$_\alpha$"-business models compared to the "As is$_\alpha$"-business model.

7.3.2 Risks

The risks of BC_α are structured as described in Section 7.2.5. Table 7.4 shows the risks of $BM_\alpha^{\text{To be}_1}$ and $BM_\alpha^{\text{To be}_2}$ compared to $BM_\alpha^{\text{As is}}$. This shows risks involved in the "To be$_\alpha$"-business models compared to the "As is$_\alpha$"-business model.

7.3.3 Costs

The costs and benefits of BC_α are structured as described in Section 7.2.6 using the scenarios as defined in Section 7.1.1. Table 7.5 and 7.6 show the cashflows for $BM_\alpha^{\text{To be}_1}$ and $BM_\alpha^{\text{To be}_2}$ compared to $BM_\alpha^{\text{As is}}$. This shows the cashflows per role over a period of five years per general practice for the "To be$_\alpha$"-business models compared to the "As is$_\alpha$"-business model.

Table 7.2: Effects compared to $BM_{\alpha}^{As\ is}$ I

Effect	Description	Owner	Business change	Explicitness	Measurement	$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$
+	Intensify relationship with laboratory	General practitioner	DNT	M	Frequency of contact with laboratory		
+	Receive test results quicker	General practitioner	DNT	Q	POCT device performance/specifications		
+	Receive test results quicker in HIS	General practitioner	DNT	M	Upload/synchronisation time; mostly within the hour		
+	More/better/accurate information from POCT device/test	General practitioner	DNT	Q	POCT device performance/specifications		
+	More/better/accurate information for clinical discussion making	General practitioner	DNT	Q	Reliability of POCT results		
+	Eliminate labour intensive administration by automated processing of test results	General practitioner	SDT	M	Handling time with courier		
+	Intensify relationship with general practitioner	Laboratory	DNT	M	Increased frequency contact with general practitioner		
+	More/better/accurate information from POCT device/test	Laboratory	DNT	Q	POCT device performance/specifications		
+	Redistribute freed capacity test equipment	Laboratory	DTB	Q	Total tests performed including POCT results		
+	Stop using courier service for test samples and printouts	Laboratory	SDT	F	Number of trips by courier		
+	Free up capacity test equipment	Laboratory	SDT	Q	Time saved by POCT devices; dependent on number of general practitioners, POCT devices and tests performed using POCT		
+	Eliminate labour intensive administration test results	Laboratory	SDT	F	Processed test results per time frame		

DNT	Do New Things
DTB	Do Things Better
SDT	Stop Doing Things

F	Financial
Q	Quantifiable
M	Measurable
O	Observable

	Non existent Benefit
	Larger benefit

Table 7.3: Effects compared to $BM_{\alpha}^{As\ is}$ II

Effect	Description	Owner	Business change	Explicitness	Measurement	$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$
-	Losing the laboratory as a customer	Courier	SDT	F	Number of trips for laboratory		
+	Improve quality public health	Health insurance company	DNT	M	Reliability clinical decision making general practitioner		
+	Reduction public health costs	Health insurance company	DNT	F	Reimbursements laboratory and general practitioner		
-	Losing general practitioner as a customer	Laboratory-HIS integration company	SDT	F	Number of POCT results		
+	Increased use of service	Laboratory-HIS integration company	DNT	F	Number of POCT results		
+	Increased use of service	MobiHealth	DNT	F	Number of POCT results		
+	Provide integrated service	MobiHealth	DNT	M	Number of POCT results		
+	Quicker diagnosis	Patient	DNT	M	POCT device performance/specifications		
+	Increased sales POCT devices	POCT device supplier	DTB	F	Number of POCT devices		

DNT	Do New Things
DTB	Do Things Better
SDT	Stop Doing Things

F	Financial
Q	Quantifiable
M	Measurable
O	Observable

	Non existent
	Benefit
	Larger benefit

Table 7.4: Risks compared to $BM_{\alpha}^{As\ is}$

Event	Owner	Probability	Impact	Response		$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$
				Mitigation	Contingency		
MobiHealth – POCT device connection failure	General practitioner	↓	↓	Reinforce (physical placement of) device	Troubleshoot using MobiHealth help desk		
No/limited submission of POCT results by general practitioner	Laboratory	↓	–	Monitor and stimulate usage of MobiHealth service	Reconsider and discuss placement of POCT at general practitioner		
Service unavailable, due to too many requests	Laboratory-HIS integration company	↓	↓	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	Laboratory-HIS integration company	⇓	↓	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		
Service unavailable, due to too many requests	MobiHealth	↓	–	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	MobiHealth	⇓	–	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		
Service unavailable, due to too many requests	MobiHealth	–	↑	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	MobiHealth	↓	↑	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		

⇑	Very high
↑	High
–	Medium
↓	Low
⇓	Very low

Table 7.5: Cashflow $BM_{\alpha}^{To\ be_1}$ 5 year period per general practice

			Scenario 1	Scenario 2	Scenario 3
Laboratory	Administration	€ 2,00	€ 7.200,00	€ 9.600,00	€ 12.000,00
	Installation POCT device	€ -6,25	€ -12,50	€ -18,75	€ -25,00
	MobiHealth integration		€ -400,00	€ -550,00	€ -700,00
	MobiHealth uploads		€ -1.080,00	€ -1.440,00	€ -1.800,00
			€ 5.707,50	**€ 7.591,25**	**€ 9.475,00**
MobiHealth	Hardware	€ -100	€ -200,00	€ -300,00	€ -500,00
	Configuration	€ -50,00	€ -100,00	€ -150,00	€ -200,00
	Integration	€ 100,00	€ 400,00	€ 550,00	€ 800,00
	Upload service	€ 0,30	€ 1.080,00	€ 1.440,00	€ 1.800,00
			€ 1.180,00	**€ 1.540,00**	**€ 1.900,00**

Table 7.6: Cashflow $BM_{\alpha}^{To\ be_2}$ 5 year period per general practice

			Scenario 1	Scenario 2	Scenario 3
Laboratory	Administration	€ 2,00	€ 7.200,00	€ 9.600,00	€ 12.000,00
	Installation POCT device	€ -6,25	€ -12,50	€ -18,75	€ -25,00
	MobiHealth integration		€ -400,00	€ -550,00	€ -800,00
	MobiHealth synchronisation		€ -2.160,00	€ -2.880,00	€ -3.600,00
			€ 4.627,25	**€ 6.151,25**	**€ 7.575,00**
MobiHealth	Hardware	€ -100	€ -200,00	€ -300,00	€ -500,00
	Configuration	€ -50,00	€ -100,00	€ -150,00	€ -200,00
	Integration	€ 100,00	€ 400,00	€ 550,00	€ 800,00
	Synchronisation service	€ 0,60	€ 2.160,00	€ 2.880,00	€ 3.600,00
			€ 2.260,00	**€ 2.980,00**	**€ 3.700,00**
General practice	LIS-HIS integration savings	€ 9180,00	€ 900,00	€ 900,00	€ 900,00
			€ 900,00	**€ 900,00**	**€ 900,00**

7.4 Business case β

Business case β (BC_β) compares the business models developed using BMM β as set out in Section 7.2.3. This comparison will be done on three dimensions: effects, risks and costs.

7.4.1 Effects

The effects of BC_β are structured as described in Section 7.2.4. Table 7.7 and 7.8 show the effects of $BM_\beta^{\text{To be}_1}$ and $BM_\beta^{\text{To be}_2}$ compared to $BM_\beta^{\text{As is}}$. This shows the positive and negative effects of the "To be$_\beta$"-business models compared to the "As is$_\beta$"-business model.

7.4.2 Risks

The risks of BC_β are structured as described in Section 7.2.5. Table 7.9 shows the risks of $BM_\beta^{\text{To be}_1}$ and $BM_\beta^{\text{To be}_2}$ compared to $BM_\beta^{\text{As is}}$. This shows risks involved in the "To be$_\beta$"-business models compared to the "As is$_\beta$"-business model.

7.4.3 Costs

The costs and benefits of BC_β are structured as described in Section 7.2.6 using the scenarios as defined in Section 7.1.1. Table 7.10 and 7.11 show the cashflows for $BM_\beta^{\text{To be}_1}$ and $BM_\beta^{\text{To be}_2}$ compared to $BM_\beta^{\text{As is}}$. This shows the cashflows per role over a period of five years per general practice for the "To be$_\beta$"-business models compared to the "As is$_\beta$"-business model.

Table 7.7: Effects compared to $BM_{\alpha}^{As\ is}$ I

Effect	Description	Owner	Business change	Explicitness	Measurement	$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$
+	Intensify relationship with laboratory	General practitioner	DNT	M	Frequency of contact with laboratory		
+	Receive test results quicker	General practitioner	DNT	Q	POCT device performance/specifications		
+	Receive test results quicker in HIS	General practitioner	DNT	M	Upload/synchronisation time; mostly within the hour		
+	More/better/accurate information from POCT device/test	General practitioner	DNT	Q	POCT device performance/specifications		
+	More/better/accurate information for clinical discussion making	General practitioner	DNT	Q	Reliability of POCT results		
+	Single contact for POCT devices	General practitioner	DNT	O	User (general practitioner) satisfaction		
+	Eliminate labour intensive administration by automated processing of test results	General practitioner	SDT	M	Handling time with courier		
+	Intensify relationship with general practitioner	Laboratory	DNT	M	Increased frequency contact with general practitioner		
+	More/better/accurate information from POCT device/test	Laboratory	DNT	Q	POCT device performance/specifications		
+	Redistribute freed capacity test equipment	Laboratory	DTB	Q	Total tests performed including POCT results		
+	Redistribute freed resources by stop selling POCT devices	Laboratory	DTB	O	N/A		
+	Stop using courier service for test samples and printouts	Laboratory	SDT	F	Number of trips by courier		
+	Free up capacity test equipment	Laboratory	SDT	Q	Time saved by POCT devices; dependent on number of general practitioners, POCT devices and tests performed using POCT		
+	Eliminate labour intensive administration test results	Laboratory	SDT	F	Processed test results per time frame		

DNT	Do New Things
DTB	Do Things Better
SDT	Stop Doing Things

F	Financial
Q	Quantifiable
M	Measurable
O	Observable

	Non existent
	Benefit
	Larger benefit

Table 7.8: Effects compared to $BM_{\alpha}^{As\ is}$ II

Effect	Description	Owner	Business change	Explicitness	Measurement	$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$
-	Losing the laboratory as a customer	Courier	SDT	F	Number of trips for laboratory		
+	Improve quality public health	Health insurance company	DNT	M	Reliability clinical decision making general practitioner		
+	Reduction public health costs	Health insurance company	DNT	F	Reimbursements laboratory and general practitioner		
-	Losing general practitioner as a customer	Laboratory-HIS integration company	SDT	F	Number of POCT results		
+	Increased use of service	Laboratory-HIS integration company	DNT	F	Number of POCT results		
+	Increased use of service	MobiHealth	DNT	F	Number of POCT results		
+	Provide integrated service	MobiHealth	DNT	M	Number of POCT results		
+	Additional revenue due to sales POCT devices	MobiHealth	DNT	F	Number of POCT devices		
+	Quicker diagnosis	Patient	DNT	M	POCT device performance/specifications		
+	Increased sales POCT devices	POCT device supplier	DTB	F	Number of POCT devices		

DNT	Do New Things
DTB	Do Things Better
SDT	Stop Doing Things

F	Financial
Q	Quantifiable
M	Measurable
O	Observable

	Non existent
	Benefit
	Larger benefit

Table 7.9: Risks compared to $BM_{\beta}^{As\ is}$

Event	Owner	Probability	Impact	Response		$BM_{\beta}^{To\ be_1}$	$BM_{\beta}^{To\ be_2}$
				Mitigation	Contingency		
MobiHealth – POCT device connection failure	General practitioner	↓	↓	Reinforce (physical placement of) device	Troubleshoot using MobiHealth help desk		
No/limited submission of POCT results by general practitioner	Laboratory	↓	–	Monitor and stimulate usage of MobiHealth service	Reconsider and discuss placement of POCT at general practitioner		
Service unavailable, due to too many requests	Laboratory-HIS integration company	↓	↓	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	Laboratory-HIS integration company	⇓	↓	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		
Service unavailable, due to too many requests	MobiHealth	↓	–	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	MobiHealth	⇓	–	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		
Service unavailable, due to too many requests	MobiHealth	–	↑	Monitor service, maintain a certain level of over capacity	Accelerated scale out		
Service unavailable, due to human error/hardware failure/etc.	MobiHealth	↓	↑	Implement testing procedures, policy and stock on hardware	Switch to fail-over systems		

⇑	Very high
↑	High
–	Medium
↓	Low
⇓	Very low

Table 7.10: Cashflow $BM_{\beta}^{To\ be_1}$ 5 year period per general practice

			Scenario 1	Scenario 2	Scenario 3
Laboratory	Administration	€ 2,00	€ 7.200,00	€ 9.600,00	€ 12.000,00
	Installation POCT device	€ -6,25	€ -12,50	€ -18,75	€ -25,00
	MobiHealth integration		€ -0,00	€ -0,00	€ -0,00
	MobiHealth uploads		€ -3.600,00	€ -4.800,00	€ -6.000,00
			€ 3.587,50	**€ 4.781,25**	**€ 5.975,00**
MobiHealth	Hardware	€ -100	€ -200,00	€ -300,00	€ -500,00
	Configuration	€ -50,00	€ -100,00	€ -150,00	€ -200,00
	Integration	€ 0,00	€ 0,00	€ 0,00	€ 0,00
	Upload service	€ 1,00	€ 3.600,00	€ 4.800,00	€ 6.000,00
			€ 3.300,00	**€ 4.350,00**	**€ 5.300,00**

Table 7.11: Cashflow $BM_{\beta}^{To\ be_2}$ 5 year period per general practice

			Scenario 1	Scenario 2	Scenario 3
Laboratory	Administration	€ 2,00	€ 7.200,00	€ 9.600,00	€ 12.000,00
	MobiHealth deployment		€ -500,00	€ -500,00	€ -500,00
	MobiHealth synchronisation		€ -3.00,00	€ -3.000,00	€ -3.000,00
			€ 3.700,00	**€ 6.100,00**	**€ 8.500,00**
MobiHealth	Hardware	€ -100	€ -200,00	€ -300,00	€ -500,00
	Configuration	€ -50,00	€ -100,00	€ -150,00	€ -200,00
	Deployment service	€ 100,00	€ 500,00	€ 500,00	€ 500,00
	Synchronisation service	€ 600,00	€ 3.000,00	€ 3.000,00	€ 3.000,00
			€ 3.200,00	**€ 3.050,00**	**€ 2.800,00**
General practice	LIS-HIS integration savings	€ 180,00	€ 900,00	€ 900,00	€ 900,00
			€ 900,00	**€ 900,00**	**€ 900,00**

7.5 Conclusion

This chapter has developed two business cases, BC_{α} and BC_{β}, by applying the BM2BC and a sensitivity analysis. By doing so, Objective 3 is complete. All research sub-questions related to Objective 3 have been answered in Section 7.1 and 7.1.1. The resulting business cases can be found in Section 7.3 and 7.4.

Not all components of BM2BC have been used. It is not within the scope of this research nor up to the researcher to select the best/suitable option and develop an implementation plan. Though enough information has been gathered to perform the alternative selection.

A more detailed conclusion of the developed business cases is available after the business case analysis in the next chapter.

8. Business case analysis

In this chapter an analysis will be performed upon the business cases developed in the previous chapter. This will be done to achieve Objective 4. In order to analyse the business cases tools are required. Unfortunately most business case methods do not provide tools for evaluation, but rather suggest a list of requirements or essential elements in the business case. Therefore this chapter will start with the design of a set of tools for business case analysis which will be used to analyse the business cases developed in Chapter 7.

8.1 Business Case Analysis Toolset

The Business Case Analysis Toolset (BCAT) provides a set of tools to gain more insight into the business case. Tools will be provided for three elements of the business case: effects, risks and costs. This allows for the analysis of the different elements of the business case. Lastly a conclusion needs to be drawn whether and to which degree the business options contribute to the business objectives stated at the start of the business case.

8.1.1 Effects radar

A radar chart can be used to display multivariate observations with an arbitrary number of variables. Each observation is represented as a star-shaped figure with one ray for each variable. For a given observation, the length of each ray is made proportional to the size of that variable [14]. THe radar chart makes it easy to see patterns in represented data. Therefore a radar chart will be used to visualise the benefits per stakeholder.

The effects radar is a tool in the BCAT toolset which aims to provide insight in the distribution of effects per option in a business case. A radar chart is constructed with a dimension for each stakeholder. A effect score needs to be calculated per stakeholder. The effect score is calculated by adding one point for each positive effect and subtract one point for each negative effect. Weights can be added to each effect if desired. Since radar chars are unable to visualise negative values, all scores need to be normalised. This normalisation need only to be performed if one ore more negative effect scores exist. To do this, add the absolute value of the smallest (negative) effect score to the scores of all stakeholders. Also draw a line to indicate the zero effect score.

Figure 8.1 shows the effects radar for the options in Business case α and Business case β compared to $BM_{\alpha}^{\text{As is}}$ and $BM_{\alpha}^{\text{To be}_1}$ based on Tables 7.2, 7.3, 7.7 and 7.8. This can be done as $BM_{\alpha}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_1}$ are based on the same e^3value model and only differ on a financial level.

The benefits for the health insurance company and POCT device supplier remain the same for all business models. The laboratory-HIS integration company loses its positive effect in $BM_{\alpha}^{\text{To be}_2}$ and $BM_{\beta}^{\text{To be}_2}$ compared to $BM_{\alpha}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_1}$, but is compensated for by MobiHealth in the last mentioned business models. $BM_{\alpha}^{\text{To be}_2}$ and $BM_{\beta}^{\text{To be}_2}$ have similar effects on the stakeholders,

but the last one does have added benefits. This is due to the fact that MobiHealth will be supplying POCT devices instead of the laboratory. The effect for the POCT device supplier remains the same whereas the actual implementation will result in an increase of effects. Overall it is clear that MobiHealth, the laboratory and the general practitioner will benefit from either of the four business models compared to $BM_{\alpha}^{As\ is}$ and $BM_{\alpha}^{To\ be_1}$.

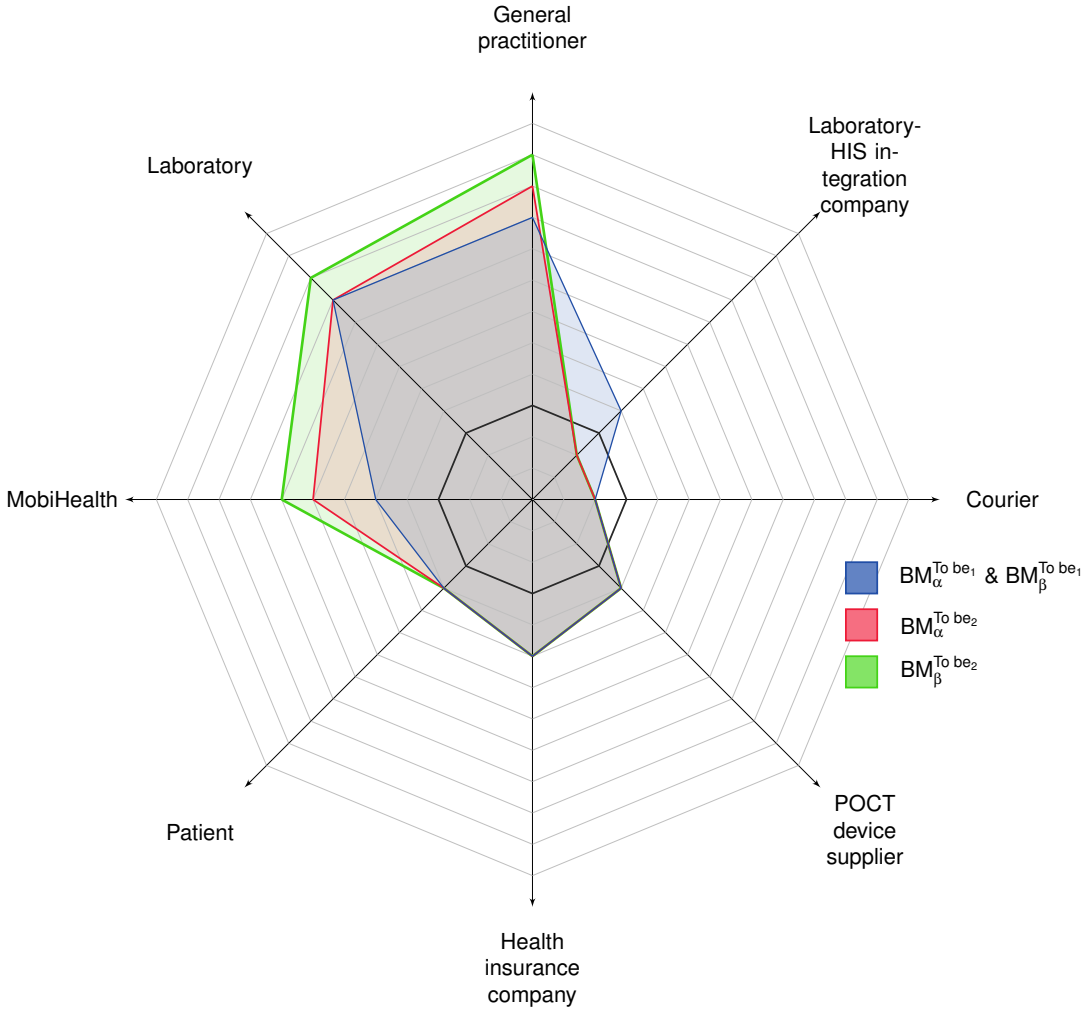

Figure 8.1: Effects radar Business case α & Business case β

8.1.2 Risks matrix

The risks matrix [6] is a tool in BCAT which aims to provide insight in the distribution of risks per option in a business case. The risks matrix of BCAT differs from most risks matrices [6] as it only provides a visual aid; individual risks are not mentioned in the matrix. A matrix is constructed with the same scales as used in the risks table in the business case to indicate the probability and impact of a risk. Outline the risks in the matrix, using dots or a surface. Use for

every option in the business case a different colour to distinguish between the risks per business model. Lastly calculate the centre of mass (geometric centre incorporating the number of risks) for each option in the business case and indicate this with an X. For example if two risks bear the same probability and impact, the centre of mass will shift towards these risks.

Figure 8.2 shows the risks matrix for the options in Business case α and Business case β compared to $BM_{\alpha}^{\text{As is}}$ and $BM_{\alpha}^{\text{To be}_1}$ as based on Table 7.4 and 7.9. $BM_{\alpha}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_1}$ have more risks compared to $BM_{\alpha}^{\text{To be}_2}$ and $BM_{\beta}^{\text{To be}_2}$. Although in numbers $BM_{\alpha}^{\text{To be}_2}$ and $BM_{\beta}^{\text{To be}_2}$ have fewer risks, the overall probability and impact has increased as can be seen by the positions of the Xs.

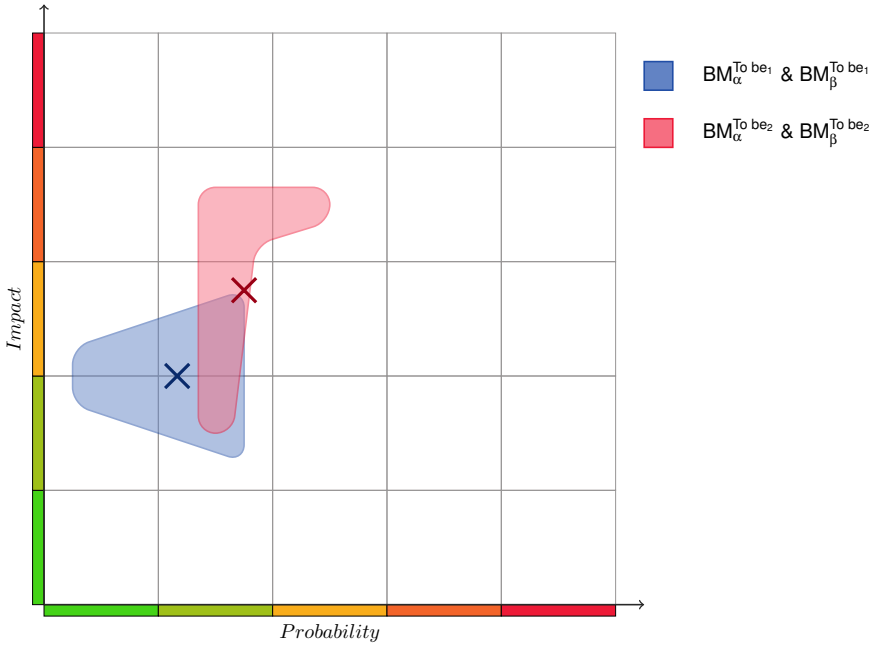

Figure 8.2: Risks Business case α & Business case β

8.1.3 Costs & Benefits radar

The costs & benefits radar is a tool in BCAT which aims to provide insight in the distribution of costs & benefits per option in a business case. First a radar needs to be drawn with a dimension for each stakeholder. Draw the different scenarios using the same colour and the different options in a different colour. Doing this will show the upper and lower bound of every option in the business case as well as the differences between those options. To represent negative numbers, offset or normalise the numbers for every stakeholder and draw a line to indicate the equilibrium.

Figure 8.3, based on Table 7.5 and 7.6, shows the benefits radar for Business case α. Several interesting facts can be seen in this figure. Firstly the distance between the lower en upper bound is greater for the laboratory than for MobiHealth indicating a wider range of potential profit. Secondly the lower bound profit for MobiHealth is greater in $BM_{\alpha}^{\text{To be}_2}$ than the upper bound in

$BM_{\alpha}^{\text{To be}_1}$. $BM_{\alpha}^{\text{To be}_2}$ is therefore the most profitable option for MobiHealth. Compared to $BM_{\alpha}^{\text{To be}_1}$ the profits for the laboratory are decreased in $BM_{\alpha}^{\text{To be}_2}$. The benefits for the general practitioner are clear, $BM_{\alpha}^{\text{To be}_1}$ does not provide any financial benefits whereas $BM_{\alpha}^{\text{To be}_2}$ does.

Figure 8.4, based on Table 7.10 and 7.11, shows the benefits radar for Business case β. The benefits for the general practitioner are the same as in Figure 8.3. The benefits are more evenly distributed among the laboratory and MobiHealth in $BM_{\beta}^{\text{To be}_1}$. The lower bound of $BM_{\beta}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_2}$ are comparable for the laboratory and MobiHealth, but the difference between lower and upper bound in $BM_{\beta}^{\text{To be}_2}$ for MobiHealth is very small whereas this difference is very large for the laboratory. Since the number of test results is the main influencer on these numbers, this shows the laboratory is able to quickly gain extra benefits by stimulating the general practitioner to perform more tests.

8.2 Conclusion

This chapter has analysed the business cases developed in chapter 7 by using the Business Case Analysis Toolset (Section 8.1. The tools have provided more insight in the dynamics of the options of BC_{α} and BC_{β}.

In the end the options of the business case aim to achieve the business objectives (Section 7.2.2). Therefore all options need to be analysed with respect to their ability to achieve the business objectives. POCT equipment provides reliable and accurate information, this contributes to the “no loss of healthcare quality” objective (Business Objective 1). As the POCT device immediately shows the test results on a display or printout, the general practitioner does not have to wait for the results to return from the laboratory. This reduces the time to clinical decision-making (Business Objective 3). The overall quality of the decision increases as more information is available to the general practitioner resulting in a better drug prescription policy. The reduction in unnecessary drug prescription (such as antibiotics) will reduce the cost of healthcare. Also as the laboratory increases efficiency by the elimination of manually entering test results into the LIS, the reimbursements paid by the health insurer can decrease; overall reducing the cost of healthcare (Business Objective 2).

$BM_{\alpha}^{\text{To be}_1}$ and $BM_{\alpha}^{\text{To be}_2}$ in BC_{α} contribute to the business objectives (Section 7.2.2) as well as $BM_{\beta}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_2}$ in BC_{β}. The extend of their contribution in made clear in Figure 8.1 (Business Objective 1 and Business Objective 3) and Figure 8.3 and 8.4 (Business Objective 2).

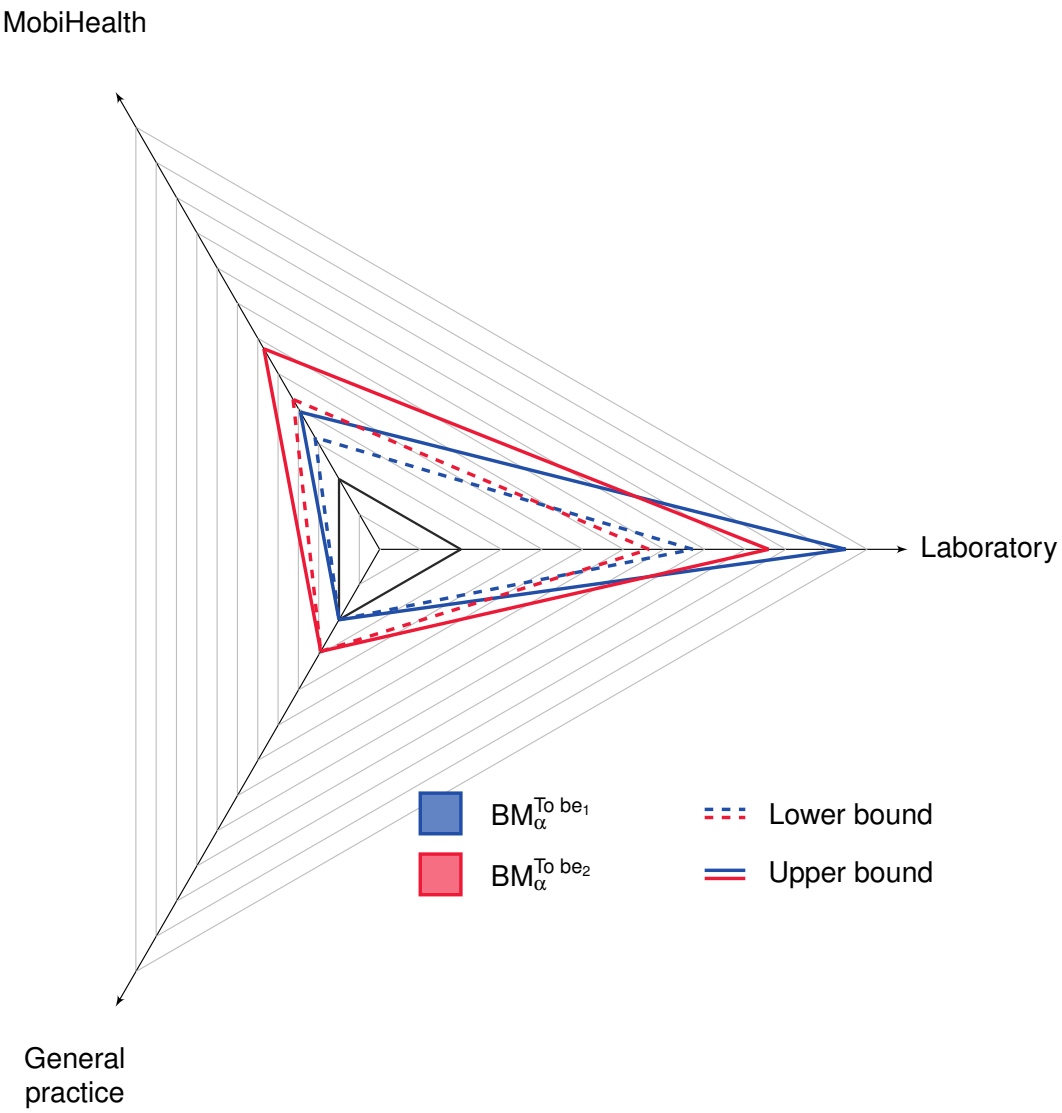

Figure 8.3: Benefits Business case α

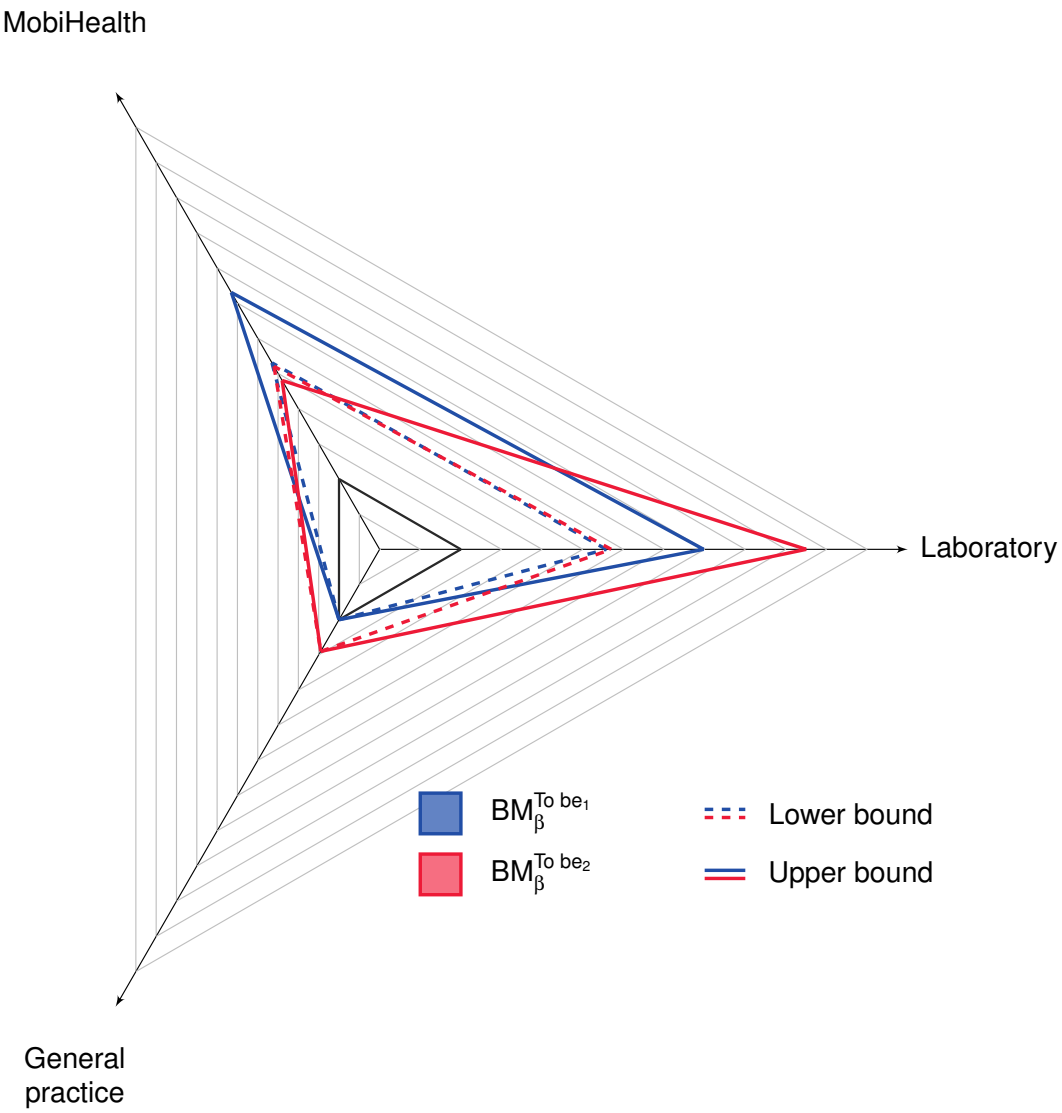

Figure 8.4: Benefits Business case β

9. Evaluation

This final chapter will evaluate the BMM derivatives (Chapter 3 and 4) on the resulting business models (Chapter 6) and business cases (Chapter 7). By doing so the last objective, Objective 5, will be completed.

9.1 Method evaluation

This section will evaluate the BMM derivatives and their influence on the resulting business models and business cases. Figure 9.1 will help structure this evaluation. The deliverables and the methods used in this research are visualised in a pyramid shape to show how the result build upon each other.

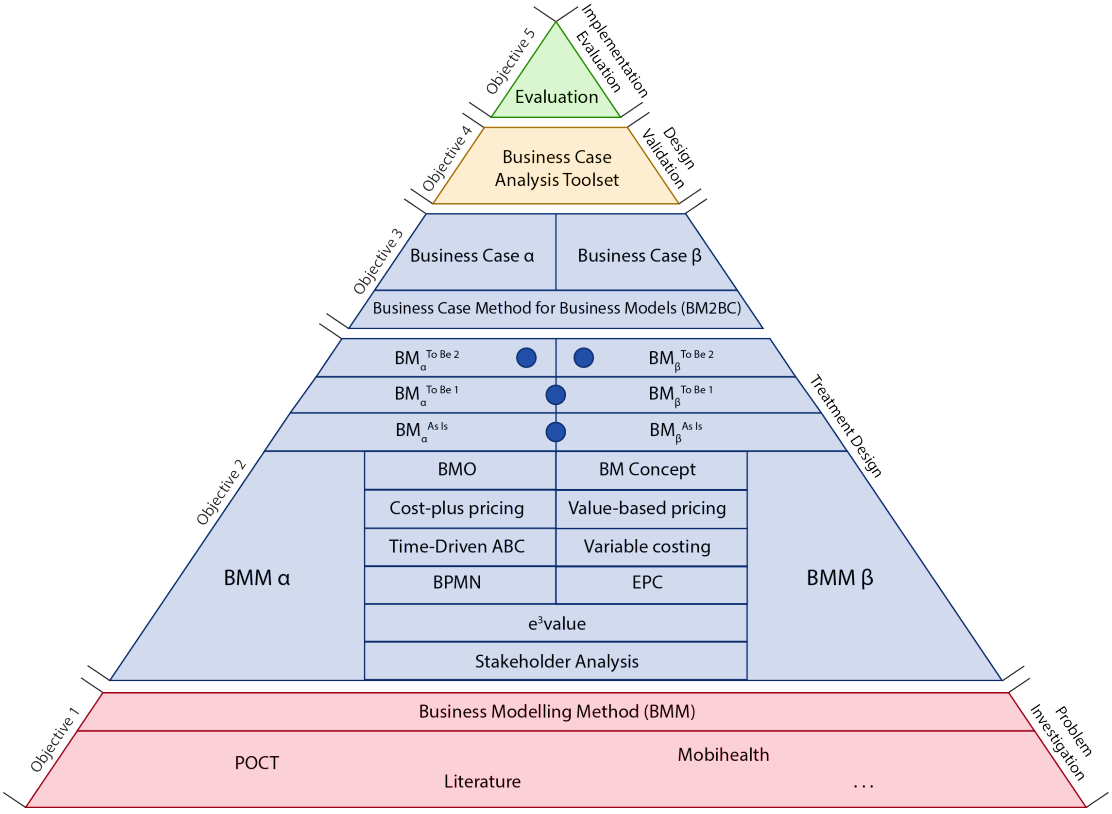

Figure 9.1: Evaluation pyramid based on the research model (Figure 1.1); copy of Figure 4.4

The use of an e^{3}value model to visualise the relationships among the stakeholder revealed the method itself has a few difficulties. Firstly it is not possible to model the more complex value exchanges. For example, it is not possible to accurately model a situation in which role α receives payment from role β while role γ uses the service of role α. This ring construction in

which all roles benefit from each other is unable to model accurately in the e^{3}value methodology. Secondly it remains a challenge to fully comply with the e^{3}value methodology as value objects are not easily identified. Although the resulting model took several iterations, overall the e^{3}value models were of value during the construction of the business models.

A pitfall has been recognised in BMM, the extensiveness of the first two steps have a large impact on the result. When roles or relationships are missed, this will result in not specifying their activities and so will not be quantified. In some cases this has to do with the scope at which BMM is applied. But in other cases roles and relationships are easily overlooked. For example the acquisition or retention of new and existing customers requires processes and thus cost resources. For a full picture of the business model such processes need to be included as well.

The third step in BMM proved to be very important as it allowed to quantify the business model by showing costs objects and points revenue was made. The difference between the used methods was not significant in terms of results. Both methods suit their purpose in specifying the activities needed to maintain value exchanges between the roles in the e^{3}value model. But there is a difference in terms of accessibility of the method. BPMN was more complete than EPC as the language was richer in elements. EPC on the other hand was easier to understand by non-technical people. For the author, to completely comply with the EPC methodology was a nightmare as it required every activity to have an event.

The difference in the cost determination in the usage of time-driven ABC and variable costing proved to be non existent. This is due to the fact that the specified activities showed no overhead. Overhead is treated differently in the different methods. When the processes are specified in more detail overhead could become visible and the used methods could/should show a difference. Time-driven ABC proved to be a very effective method to calculate the costs as it was very easy to obtain the time it took to complete an activity (simple time measurements). Quantifying the processes specified in the previous step follows a natural path, but is also limits the quantification of the business model. Costs on infrastructure, human capital or other fixed costs are not covered by BMM.

The addition of a pricing method, as discussed in Chapter 4, proved to be useful; certainly in the development of the business cases. The cost-plus pricing method was fairly easy to implement and ensured that costs were covered. The value-based pricing method allowed for a new perspective and focussed on environmental and strategic factors to incorporate into the price. It is important to note that the costs for one role can be the price for an other role (not always), though most costs need to be converted using a pricing method or are internal costs.

The addition of a meta-business model, as discussed in Chapter 4, also proved to be useful. The information gathered in the previous steps of BMM was overwhelming and a bit unstructured. The meta-business model organised and visualised the information. It could be argued that this step is just a rearrangement of information and does not help the development of a business model forward. This is true, but it does help in obtaining a better understanding of the information available and allows for easy communication with others. The author found BMO visually more appealing than BM Concept, but BM Concept focussed more on the relation between the components of the business model.

After the business models were developed, the Business Case method for Business Models (BM2BC) was used to create business cases. BM2BC Listed the components required to build a business case. However no relationship or method existed to derive effects and risks from the

business models. Therefore we are unable to verify the completeness of those components. The cost/benefits component was trivial given the two quantitative steps in BMM α and BMM β. This again proved the value of the added pricing method to BMM. Resource restrictions are considered not a real problem in BM2BC which is a pitfall. Meaning human capital or liquidity requirements are not considered in the method and thus will not come forth in the business case. They might come up in the implementation planning stage of the business case, but is should be under consideration during the decision making in the alternative selection stage.

The Business Case Analysis Toolset (BCAT) developed in Chapter 8 provided tools to gain more insight in the dynamics of the different options in the business cases. The effects radar showed how the positive and negative effects are distributed among the different business models. The risks per business model were mapped on a matrix. This clearly showed how overall the risks is shaped and which alternative involved the most risk. The cost & benefits radar showed the financial dynamics of each business model. All these tools visually provided more insight in the business cases and the differences per business model.

9.2 Conclusion

Concluding BMM and ultimately the derivatives BMM α and BMM β proved to be a useful method to build business models. It provided a natural logical structured method covering all components of a business model. BM2BC was used to create the business cases. The method was solely chosen because of its focus on business models and provided, similar to any other business case method, a list of components which should be included in a business case.

The e^{3}value model proved to be useful. It extended the role-relationship matrix by showing the value exchanges for each relationship. To maintain the relationships, the activities were modelled. In terms of communication to non-technical people EPC was the best choice, but if the goal is to later develop a business support tool BPMN should be used. As the activities showed no overhead (probably due to the level of detail) the methods used to calculate the costs showed no differences. Also the cost determination is likely to be incomplete as BMM specifies only to quantify the specified activities. The added pricing method made it possible to calculate the benefits in the business case and was therefore essential to be included in the business model. The meta-business model visually summarised the business model making it ideal to communicate to others.

Reflecting on the impact the methods had on the resulting business models and business cases. As the circles in Figure 4.4 indicate $BM_{\alpha}^{\text{As is}}$ and $BM_{\beta}^{\text{As is}}$ reflect the same situation as do $BM_{\alpha}^{\text{To be}_1}$ and $BM_{\beta}^{\text{To be}_1}$. The business cases (Chapter 7) and business case analysis (Chapter 8) show there is no difference in the effects and risks, but only on the financial level. This makes sense as effects and risks are posed by the activities whereas the financial difference is caused by the different methods (and thus numbers) used. $BM_{\alpha}^{\text{To be}_2}$ and $BM_{\beta}^{\text{To be}_2}$ on the other hand model two different situations and therefore do show a difference in effects and risks as well as on a financial level. As they model two different situations, the activities required differ as well. The business cases, and certainly the business case analysis, makes us aware of these differences as it explicitly visualises these.

10. Conclusions

This last chapter concludes this research. All objectives have been achieved; all research sub-questions have been answered. Remains to conclude on the main research question.

"What are viable business models and business cases for Point-Of-Care Testing?"

Viable business models for Point-Of-Care Testing are $BM_{\alpha}^{To\ be_1}$, $BM_{\beta}^{To\ be_1}$, $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$ (Chapter 6). The viability is shown in the business cases BC_{α} and BC_{β} (Chapter 7). This can be concluded from the business case analysis (Chapter 8). The analysis shows $BM_{\alpha}^{To\ be_1}$, $BM_{\beta}^{To\ be_1}$, $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$ have positive non-financial and financial benefits. $BM_{\alpha}^{To\ be_1}$ and $BM_{\beta}^{To\ be_1}$ are less risky than $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$, but the last two do provide financial benefits for the general practitioner (apart from the non-financial benefits).

Point-Of-Care Testing (POCT) enables clinical tests at or near the patient with the assumption that test results will be available instantly or in a very short time frame to assist caregivers with immediate diagnosis and/or clinical intervention. The goal of POCT is to provide accurate, reliable, fast and cost-effective information about patient condition. POCT can be part of the solution to the rising healthcare and welfare costs in the Netherlands and other developed countries without any loss of healthcare quality. POCT shortens the time for clinical decision-making about additional testing or therapy, as transport and preparation of clinical samples no longer causes delays, and biochemical-test results are available at the point of care rapidly.

MobiHealth is a Dutch company that was founded in 2007. The company's roots lie in the European projects MobiHealth and HealthService24. In these projects, a prototype for mobile telemonitoring was designed, tested and clinically validated in several European countries. MobiHealth has developed a service to automatically process POCT test results. The four business models ($BM_{\alpha}^{To\ be_1}$, $BM_{\beta}^{To\ be_1}$, $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$) implement the service of MobiHealth to push the POCT test results to the laboratory eliminating the need for a courier. $BM_{\alpha}^{To\ be_1}$ and $BM_{\beta}^{To\ be_1}$ (Section 6.3) use existing infrastructure to synchronise back with the information system of the general practitioner. $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$ (Section 6.4 and 6.5) integrate the back synchronisation into the MobiHealth service thus eliminating the need for a third party. In $BM_{\beta}^{To\ be_2}$ (Section 6.5) the responsibility of the laboratory to deploy POCT equipment is shifted towards MobiHealth.

The Business Case Analysis Toolset (Section 8.1) visually provided a lot of information to analyse the business cases and so the differences between the business models. The effects radar, for example, indistinguishably made clear which roles mainly profited from business models (MobiHealth, laboratory and general practitioner), even though the business cases themselves contained all necessary information. By using BCAT the risks per business model was visualised as well as an rough estimation of the average risks per business model to easily compare the risk profiles. The dynamics of the financial benefits were shown in a radar. The radar incorporated two scenarios per business model from which new conclusions could be drawn. For example $BM_{\beta}^{To\ be_2}$ provides a stable profit for MobiHealth whereas the laboratory has a huge potential with a very descent minimum profit.

All in all the financial and non-financial benefits of $BM_{\alpha}^{To\ be_2}$ and $BM_{\beta}^{To\ be_2}$ show those are the most viable business models for POCT, but $BM_{\alpha}^{To\ be_1}$ and $BM_{\beta}^{To\ be_1}$ pose less risks and are viable as well.

10.1 Limitations

This section covers the limitations of this research. A few assumptions are made in this research which need to be addressed.

The assumptions on value (for example hourly rate) used in the first and second quantification of the business model impacts the calculation of the costs and benefits made by laboratory and MobiHealth. Though argumentation is made for every value, it is clear from the business cases that the slightest increase or decrease can have an impact. Also in $BM_{\beta}^{To\ be_2}$ prices are set per POCT device rather than per test result uploaded. This has been a strategical decision highly impacting the financial outcome of the business case (BC_{β}).

The level of detail at which the processes are modelled might be to high to reveal any overhead in the process. Overhead was a depended in variable costing which could make a difference in the calculations between the methods used. Though any level was better than none and the current models do provide enough insight to perform calculations upon. Still some calculations were unable to be performed as this would require specifics on an individual basis. THe calculations for the transport process were neglected as it was highly depended on the distance between the laboratory and general practice as well as the route taken by the courier.

The scenarios used for the sensitivity analysis in the development of the business cases were based on the case study and interviews. Not incorporated in this research are the distribution of the different scenarios. The distribution could be used to calculate a single outcome for every stakeholder group rather than an outcome per general practice.

As stated earlier, it is unknown whether all effects and risks are covered in the business cases. The most obvious ones have been covered, but it needs to be noted that the identification of effects and risks is subject to the cognitive capabilities of the researcher. The researcher could also (unknowingly) have decided a certain effect or risk is outside the scope the business model and business case.

Coverage remains an issue. Following the Business Modelling Method ensures all value exchanges will be facilitated (covered) by processes; which produce costs and revenue. But processes also exist outside the value exchange model (e^3value). For example the acquisition or retention of new and existing customers require processes costing resources, but this is mostly not incorporated in the business model. Arguably because these processes exist regardless of the business model, but for starting businesses an expends which could be easily overlooked. The included value exchanges (recognised relationships) between roles determine which activities will be specified and thus calculated. Therefore only processes necessary to maintain the identified relationships are incorporated into the calculations made in this research.

Lastly the difference between theory and practice. The business models and business cases assume only a single business model can be in existences at a time. The “To be”-business models remove the need for a courier, while in practice the courier still plays part in transporting reagents. Also not all test can be performed by POCT devices, requiring either the patient to go the the laboratory or a courier to transport a test sample (as per the “As is”-business models). In essence there will always be a combination of “As is” and “To be”-business models; a sort of hybrid business model.

10.2 Research contribution

In this section the academic added value, or research contribution, will be discussed. First of all, the Business Modelling Method (BMM) can add an other success story to its track record. BMM showed to be an easy to use method providing a natural and logical structure for the development of business models. Research revealed BMM was incomplete and is missing some components. This research extended BMM by adding two more steps: “Quantify model II” and “Model modelling” (Chapter 4). The first added step allowed to further quantify the business model by providing a method to calculate the revenue. This step is also needed to build the business case. The second and last added step included a way to visualise the business model by means of a meta-business model. The visualisation makes it easy to understand by and communicate to and others.

After the business models were constructed, The Business Case method for Business Models (BM2BC) was used to develop the business cases. The sole difference with other business case methods is that BM2BC specifically focusses on business models. Only because of this reason was BM2BC used. This research showed BM2BC served its purpose and should be considered when building a business case based on multiple business models.

The developed business cases were analysed in Chapter 8 using the Business Case Analysis Toolset (BCAT). BCAT provided tools to gain more insight in the dynamics of the business case. The tools could be used in the “Alternative selection” component of BM2BC. The tools could also be used in conjunction with other business case methods both during and after the development of the business case.

This entire research has been done to evaluate the influence of the methods used on the resulting business models and business cases. The results (Section 9.1) are of academic value. The evaluation showed the usefulness and influence of the methods in the construction of the business models and business cases as well as the shortcomings and pitfalls.

Lastly the case study (Section 5.1), the business models (Chapter 6) and the business cases (Chapter 7) can be used by other researchers and provide insight into the current state of Point-Of-Care Testing.

10.3 Future research

This section discusses what researchers can do to further deepen the understanding of the matter. As far as we can see future research could go into a few directions:

1. Deepen the case study and add more detail to the business models and business cases. By adding more detail to the specified activities (process models) overhead can be made clear, processes redesigned and other sources of cost and revenue can become visible.
2. Broaden the business models by applying the business models (possibly with slight adjustments) to other sectors. The general concept of placing equipment near the place of decision making and automating the processing of data generated by the equipment could be a step forward in other sectors.
3. Come up with new business models for the MobiHealth case; for example, POCT devices at the patients home.

4. Further research to the developed BMM extensions (added steps in Chapter 4) in terms of validation or mapping to other meta-business models (similar to Table 4.3 and 4.4).
5. The sole distinction between BM2BC and other business case methods is its focus on business models; research needs to be conducted to determine whether or not this is sufficient enough.
6. BM2BC does not provide a method to derive effects and risks, new research could provide a method giving BM2BC a distinctive edge.
7. Research the usefulness of BMM α and BMM β in other areas or case studies.
8. Research the usefulness, and extend if necessary, the Business Case Analysis Toolset (Section 8.1).

Obviously future research could also go into questioning the assumptions made in this research as stated in the limitations (Section 10.1). Implementing one (or more) of the developed business models would be highly interesting, certainly over time in comparison to the calculations made in the business cases.

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A. Role-relationship matrices

Table A.1: Role-relationship matrix without MobiHealth; used in $BM_{\alpha}^{As\ is}$ and $BM_{\beta}^{As\ is}$ (Section 6.1.2 and 6.2)

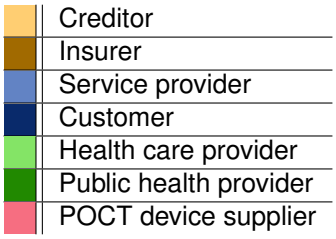
	Courier	General practitioner	Health insurance company	Laboratory	Laboratory-HIS integration company	MobiHealth	Patient	POCT device supplier
Courier				***				
General practitioner								
Health insurance company								
Laboratory		*						
Laboratory-HIS integration company		**						
MobiHealth								
Patient								
POCT device supplier								

Creditor
Insurer
Service provider
Customer
Health care provider
Public health provider
POCT device supplier

* Reagents supply service & Test processing service
** Laboratory integration service
*** Transport service

Table A.2: Role-relationship matrix with MobiHealth; used in $BM_{\alpha}^{To\ be_1}$ and $BM_{\beta}^{To\ be_1}$ (Section 6.1.2 and 6.3)

	Courier	General practitioner	Health insurance company	Laboratory	Laboratory-HIS integration company	MobiHealth	Patient	POCT device supplier
Courier								
General practitioner								
Health insurance company								
Laboratory		*						
Laboratory-HIS integration company		**						
MobiHealth				***				
Patient								
POCT device supplier								



* Reagents supply service
** Laboratory integration service
*** Upload service & POCT device integration service

Table A.3: Role-relationship matrix for MobiHealth taking over LIS-HIS integration; used in $BM_{\alpha}^{To\ be_2}$ (Section 6.4)

	Courier	General practitioner	Health insurance company	Laboratory	Laboratory-HIS integration company	MobiHealth	Patient	POCT device supplier
Courier								
General practitioner								
Health insurance company								
Laboratory		*						
Laboratory-HIS integration company								
MobiHealth				**				
Patient								
POCT device supplier								

Creditor
Insurer
Service provider
Customer
Health care provider
Public health provider
POCT device supplier

* Reagents supply service
** Synchronisation service & POCT device integration service

Table A.4: Role-relationship matrix for MobiHealth providing synchronisation service; used in $BM_{\beta}^{To\ be_2}$ (Section 6.5)

	Courier	General practitioner	Health insurance company	Laboratory	Laboratory-HIS integration company	MobiHealth	Patient	POCT device supplier
Courier								
General practitioner								
Health insurance company								
Laboratory		*						
Laboratory-HIS integration company								
MobiHealth				**				
Patient								
POCT device supplier								

Creditor
Insurer
Service provider
Customer
Health care provider
Public health provider
POCT device supplier

* Reagents supply service
** Synchronisation service & POCT deployment service

B. BPMN PROCESS MODELS

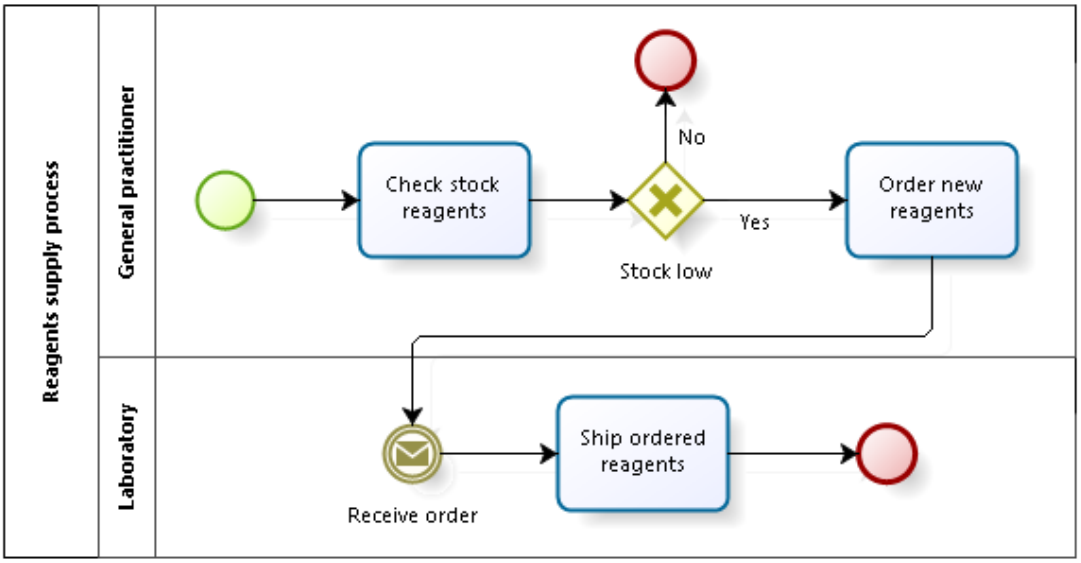


Figure B.1: Reagents supply process; used in $BM_{\alpha}^{As\ is}$, $BM_{\alpha}^{To\ be_1}$ and $BM_{\alpha}^{To\ be_2}$

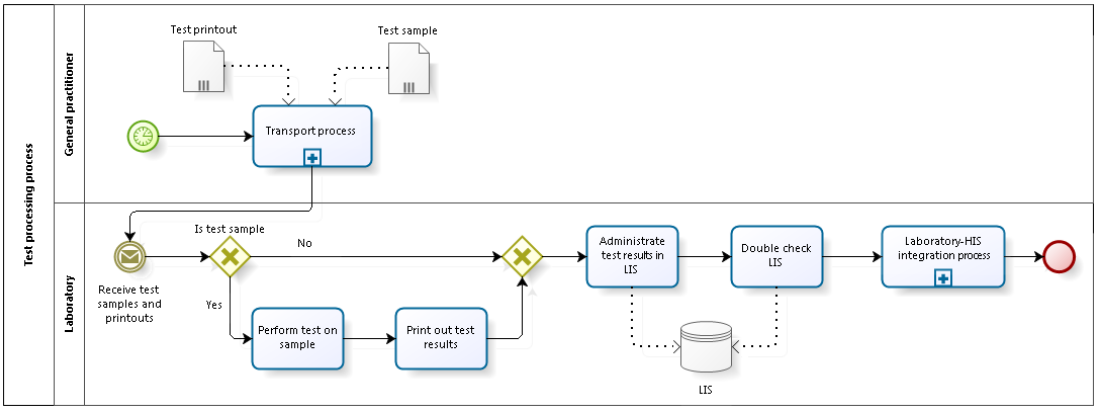


Figure B.2: Test processing process; used in $BM_{\alpha}^{As\ is}$

Table B.1: Usage of BPMN models

	$BM_{\alpha}^{As\ is}$	$BM_{\alpha}^{To\ be_1}$	$BM_{\alpha}^{To\ be_2}$	
Figure B.1	■	■	■	Reagents supply process
Figure B.2	■			Test processing process
Figure B.3	■			Transport process
Figure B.4	■	■		Laboratory-HIS integration process
Figure B.5		■	■	POCT device integration process
Figure B.6		■		Test upload process v1
Figure B.7			■	Test upload process v2
	Section 6.2	Section 6.3	Section 6.4	

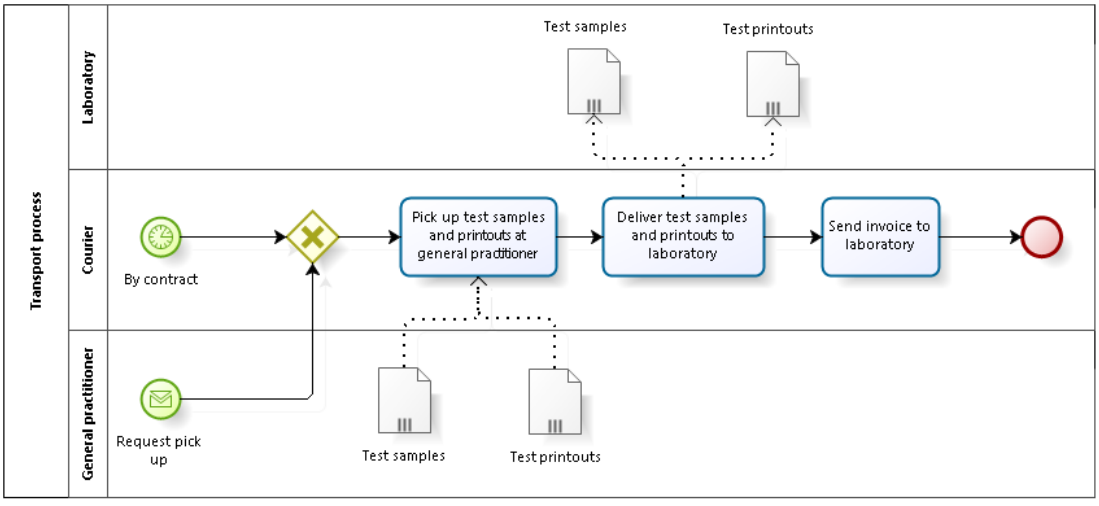


Figure B.3: Transport process; used in $BM_{\alpha}^{As\ is}$

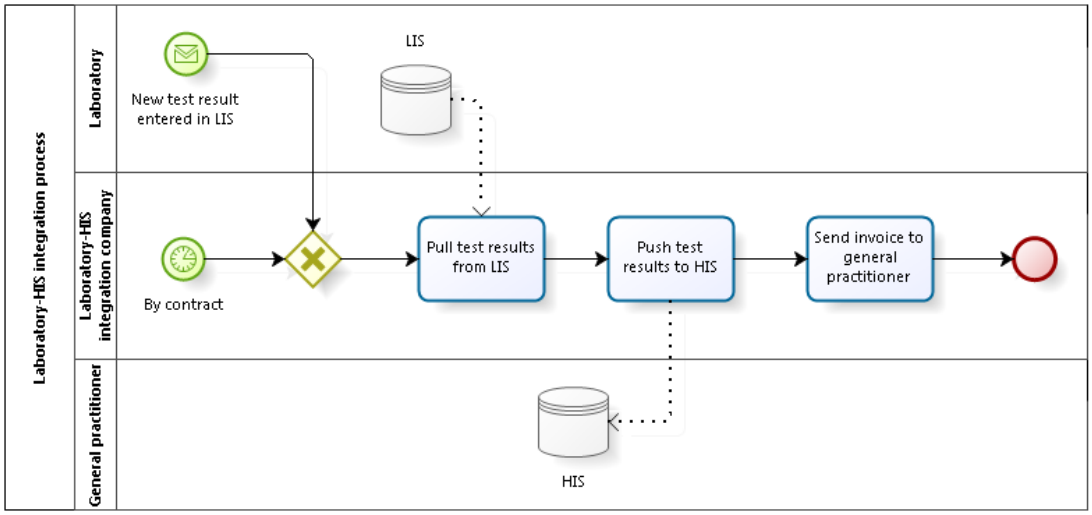


Figure B.4: Laboratory-HIS integration process; used in $BM_{\alpha}^{As\ is}$ and $BM_{\alpha}^{To\ be_1}$

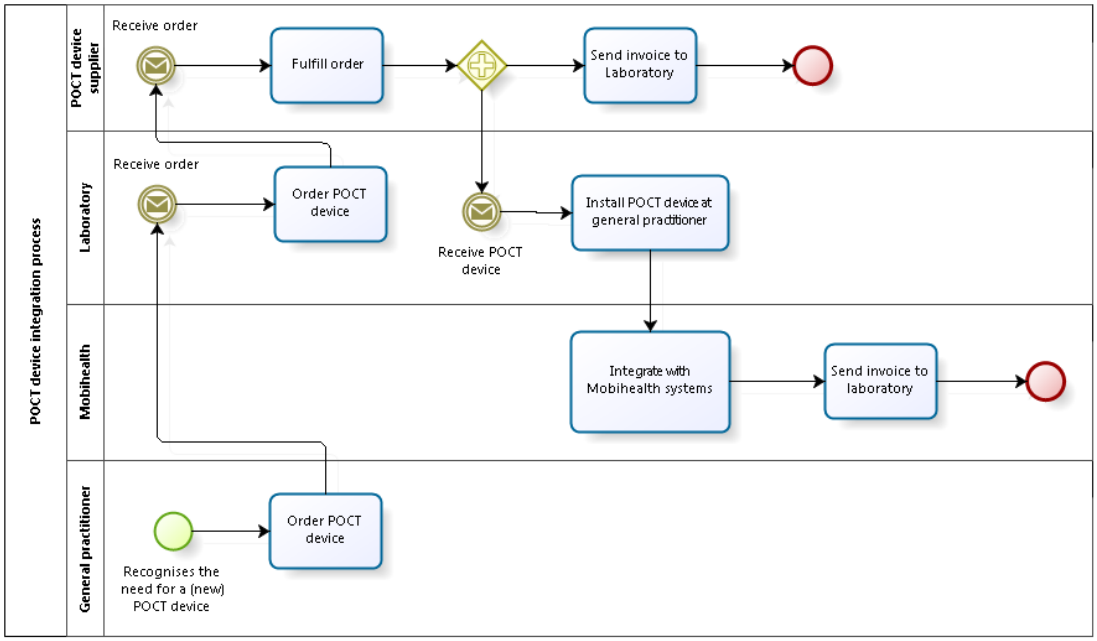


Figure B.5: POCT device integration process; used in $BM_{\alpha}^{To\ be_1}$ and $BM_{\alpha}^{To\ be_2}$

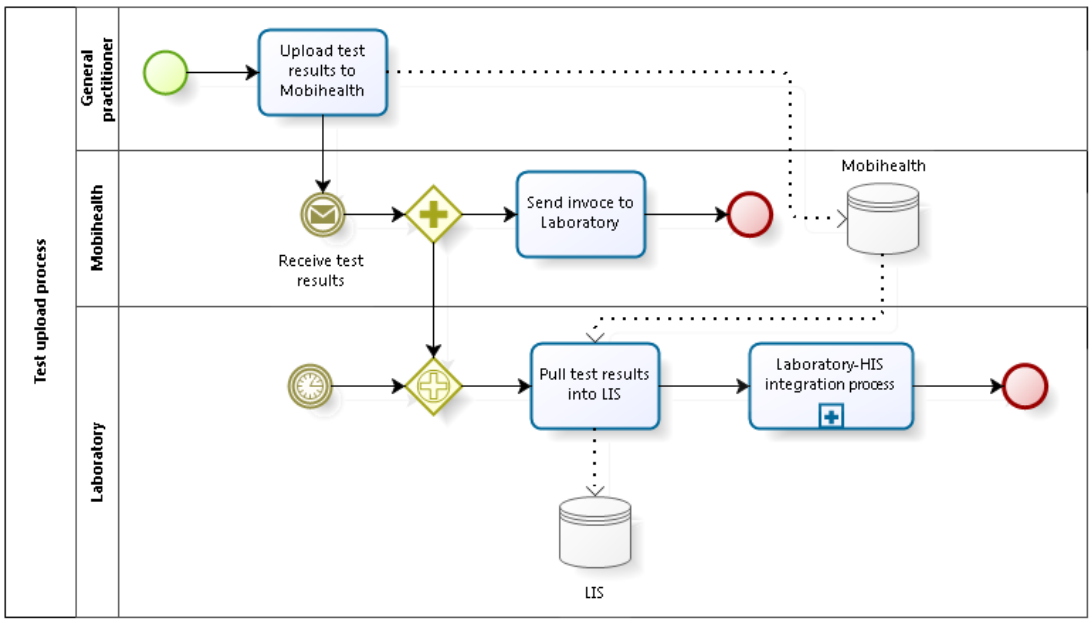


Figure B.6: Test upload process v1; used in $BM_{\alpha}^{\text{To be}_1}$

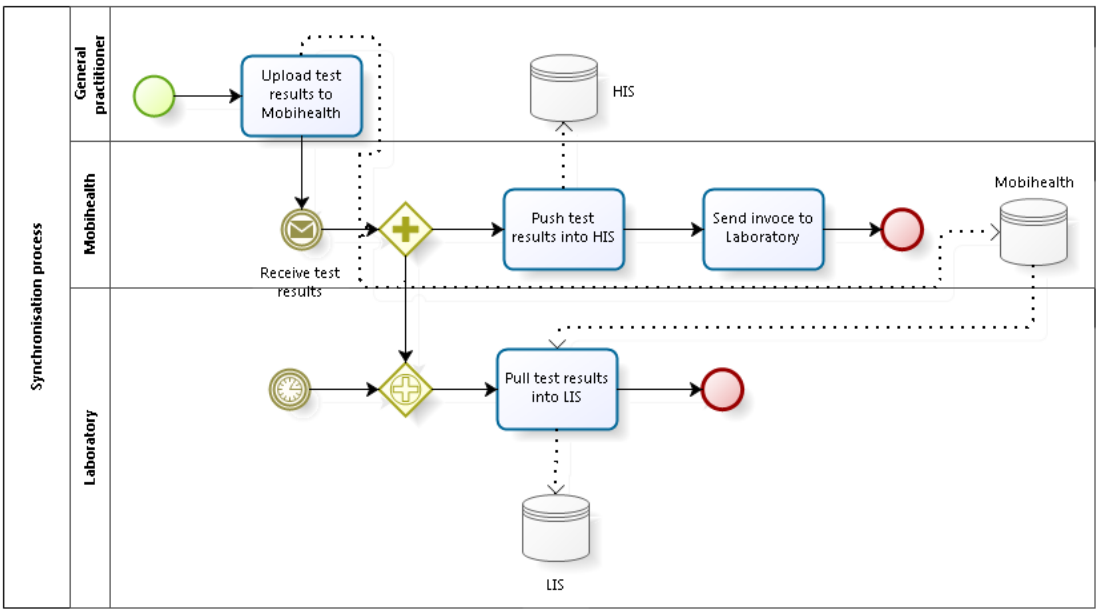


Figure B.7: Test upload process v2; used in $BM_{\alpha}^{\text{To be}_2}$

C. EPC PROCESS MODELS

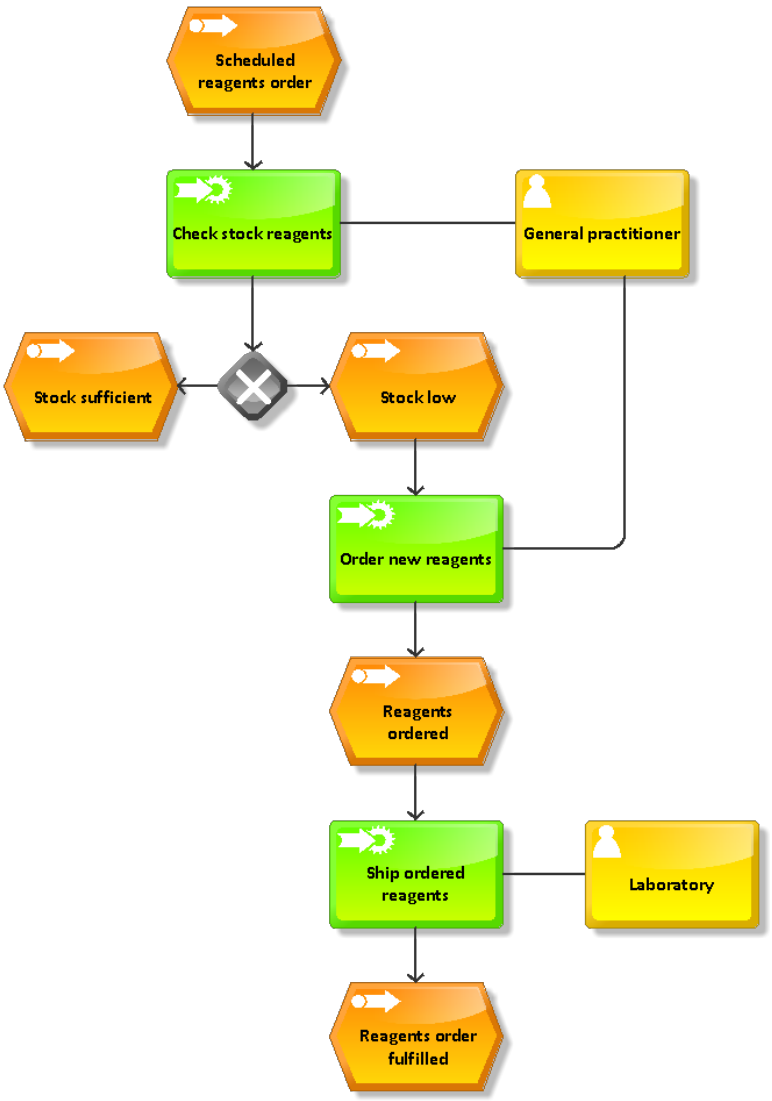


Figure C.1: Reagents supply process; used in $BM_{\beta}^{As\ is}$, $BM_{\beta}^{To\ be_1}$ and $BM_{\beta}^{To\ be_2}$

Table C.1: Usage of EPC models

	$BM_{\beta}^{As\ is}$	$BM_{\beta}^{To\ be_1}$	$BM_{\beta}^{To\ be_2}$	
Figure C.1	■	■	■	Reagents supply process
Figure C.2	■			Test processing process
Figure C.3	■			Transport process
Figure C.4	■	■		Laboratory-HIS integration process
Figure C.5		■		POCT device integration process
Figure C.6		■		Test upload process
Figure C.7			■	POCT deployment process
Figure C.8			■	Synchronisation process
	Section 6.2	Section 6.3	Section 6.5	

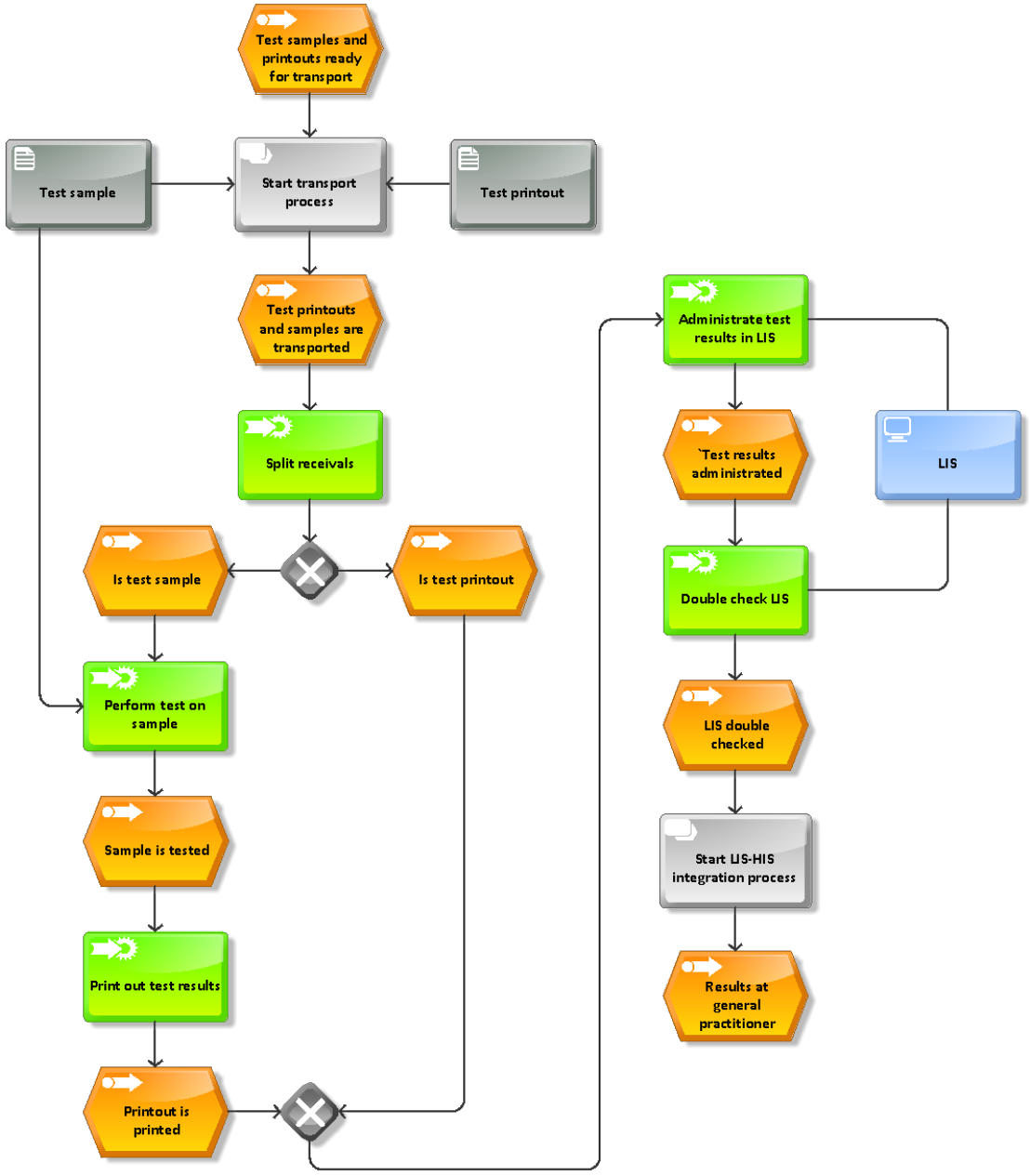


Figure C.2: Test processing process; used in $BM_{\beta}^{As\ is}$

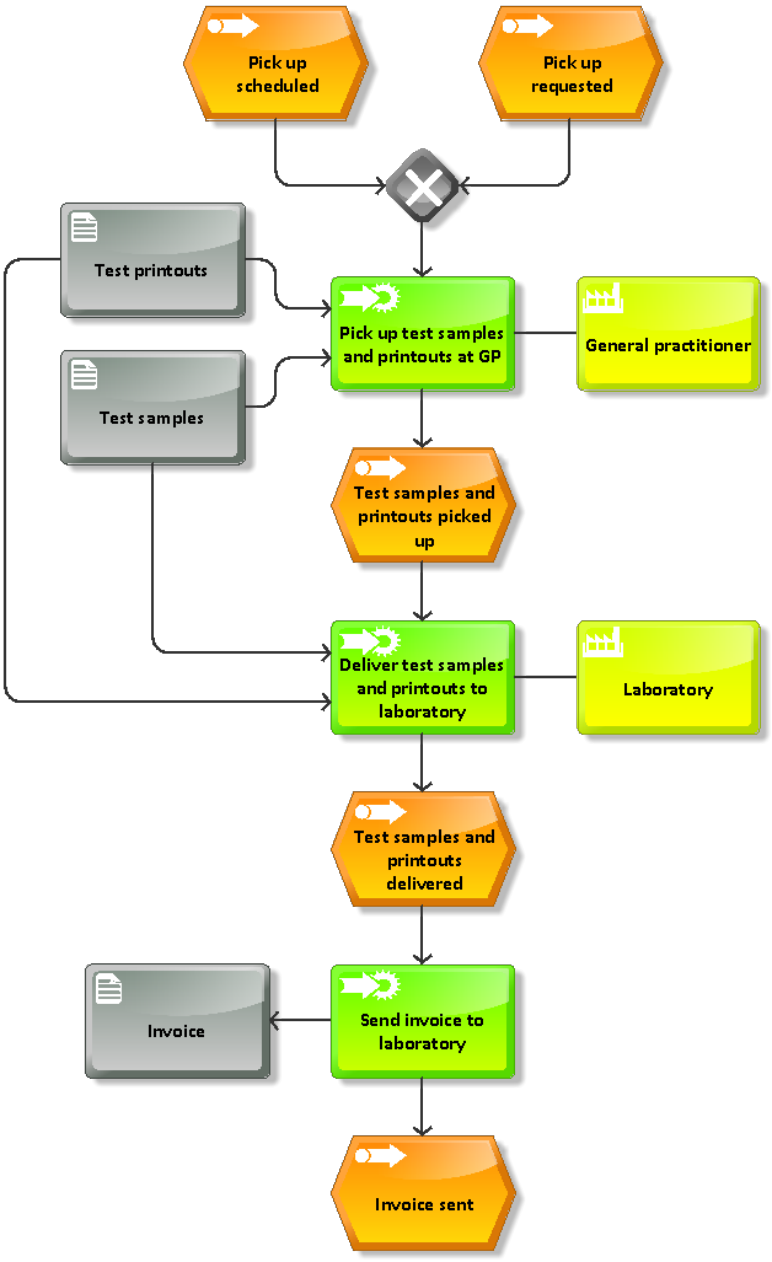


Figure C.3: Transport process; used in $BM_{\beta}^{As\ is}$

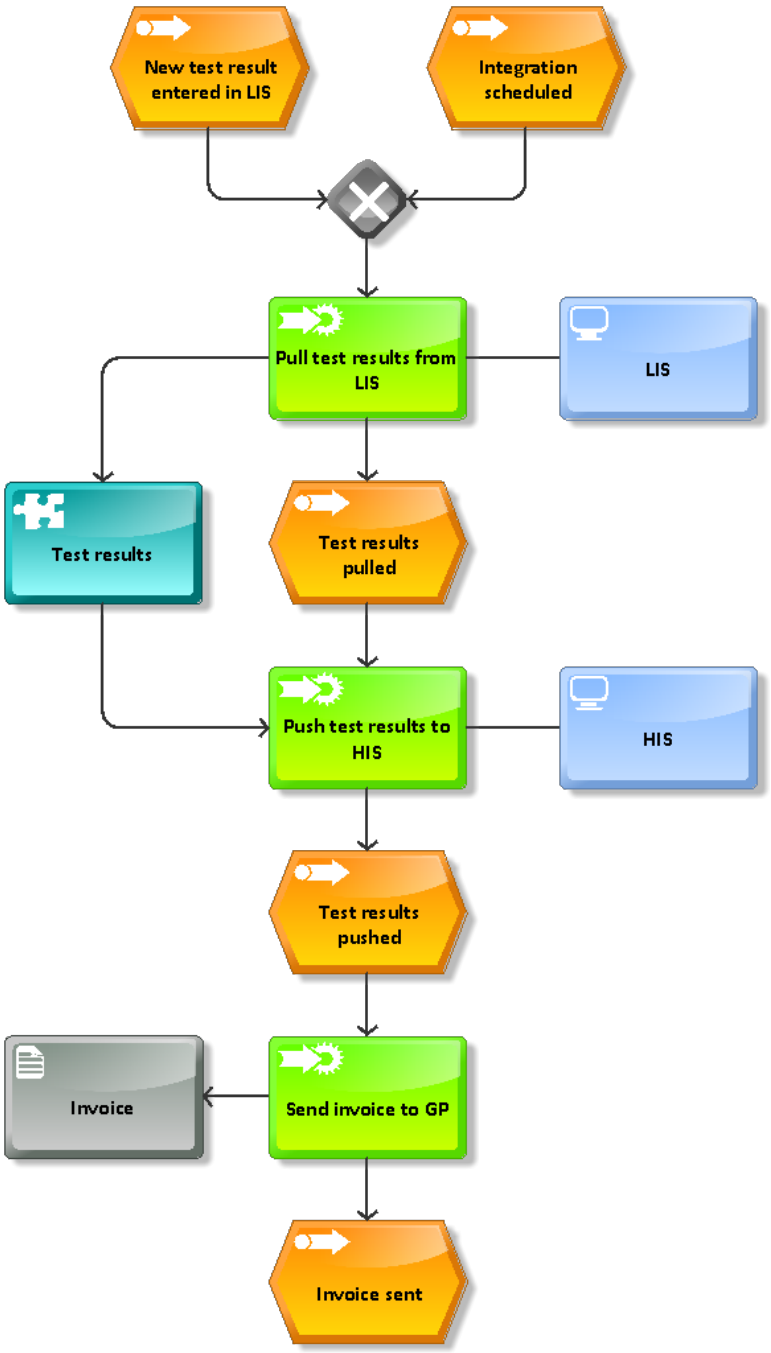


Figure C.4: Laboratory-HIS integration process; used in $BM_{\beta}^{As\ is}$ and $BM_{\beta}^{To\ be_1}$

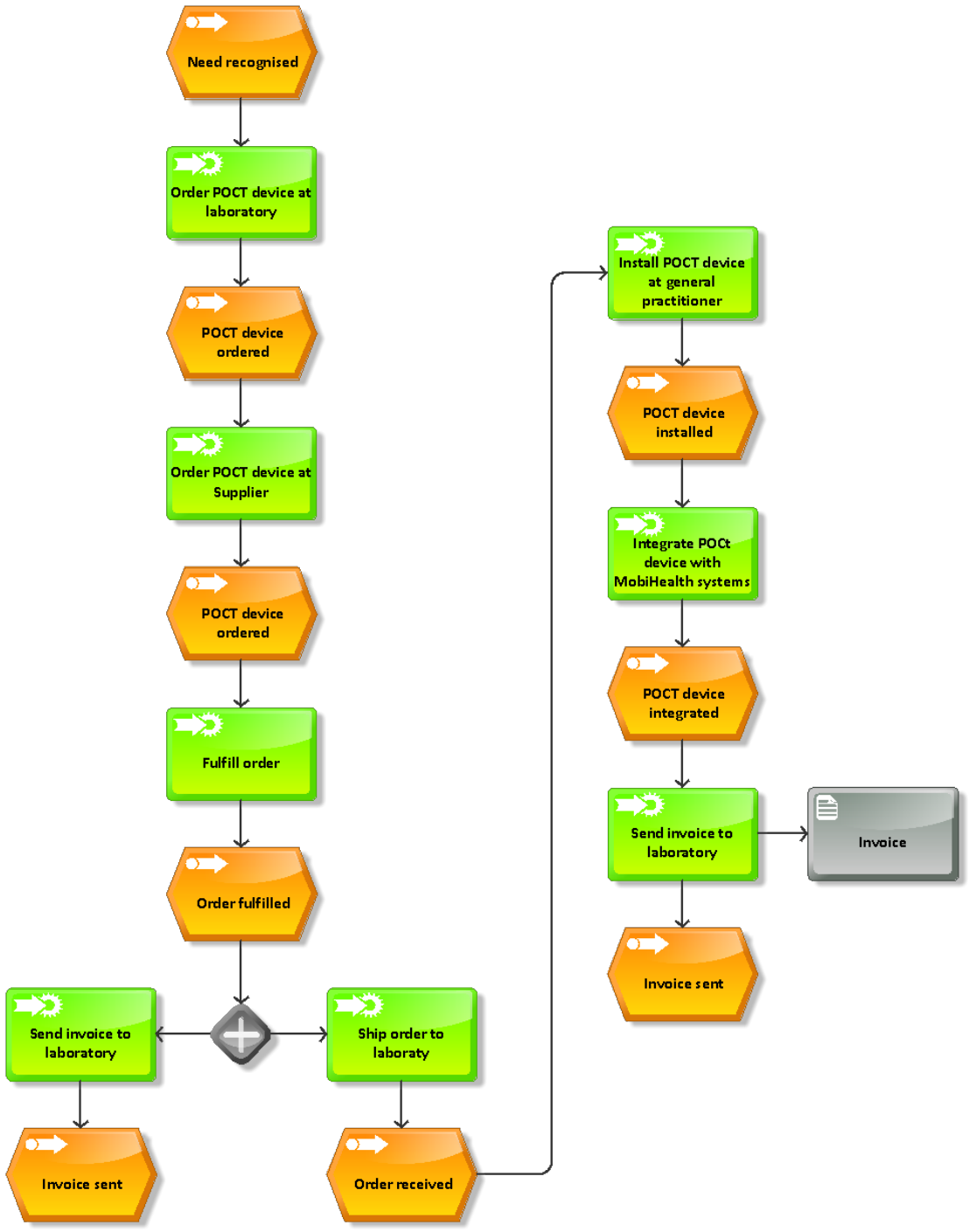


Figure C.5: POCT device integration process; used in $BM_{\beta}^{\text{To be}_1}$

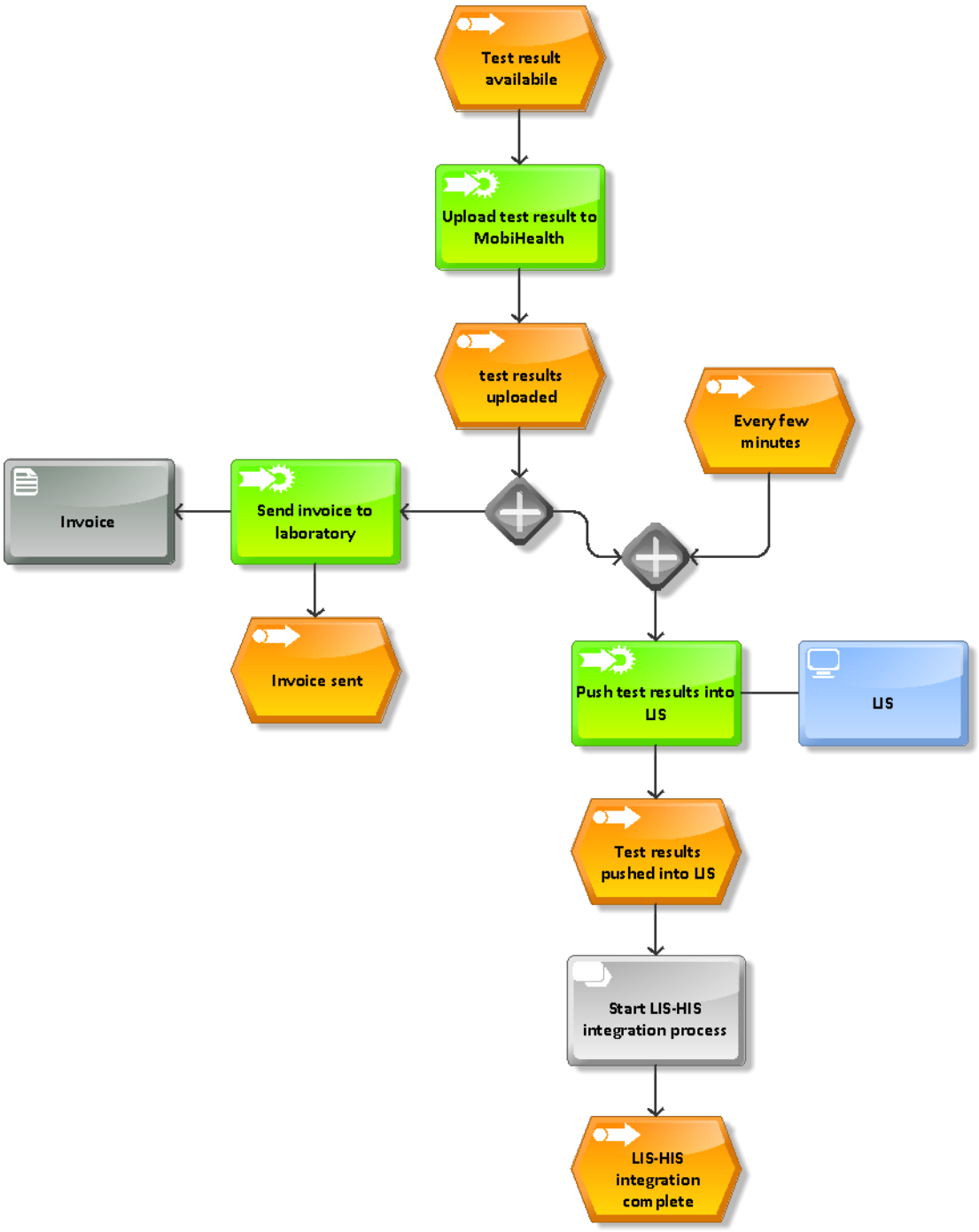


Figure C.6: Test upload process; used in $BM_{\beta}^{\text{To be}_1}$

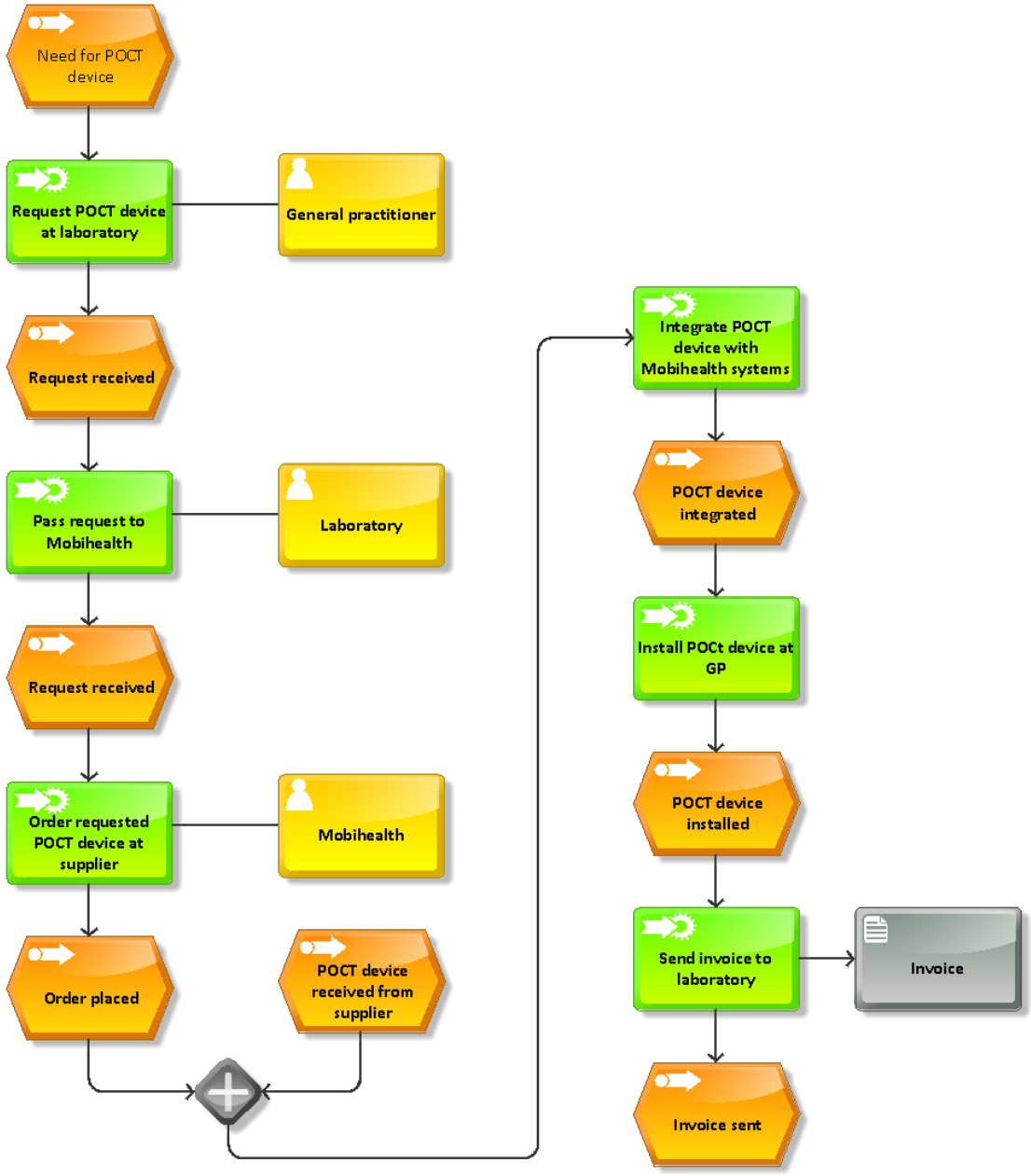


Figure C.7: POCT deployment process; used in $BM_{\beta}^{\text{To be}_2}$

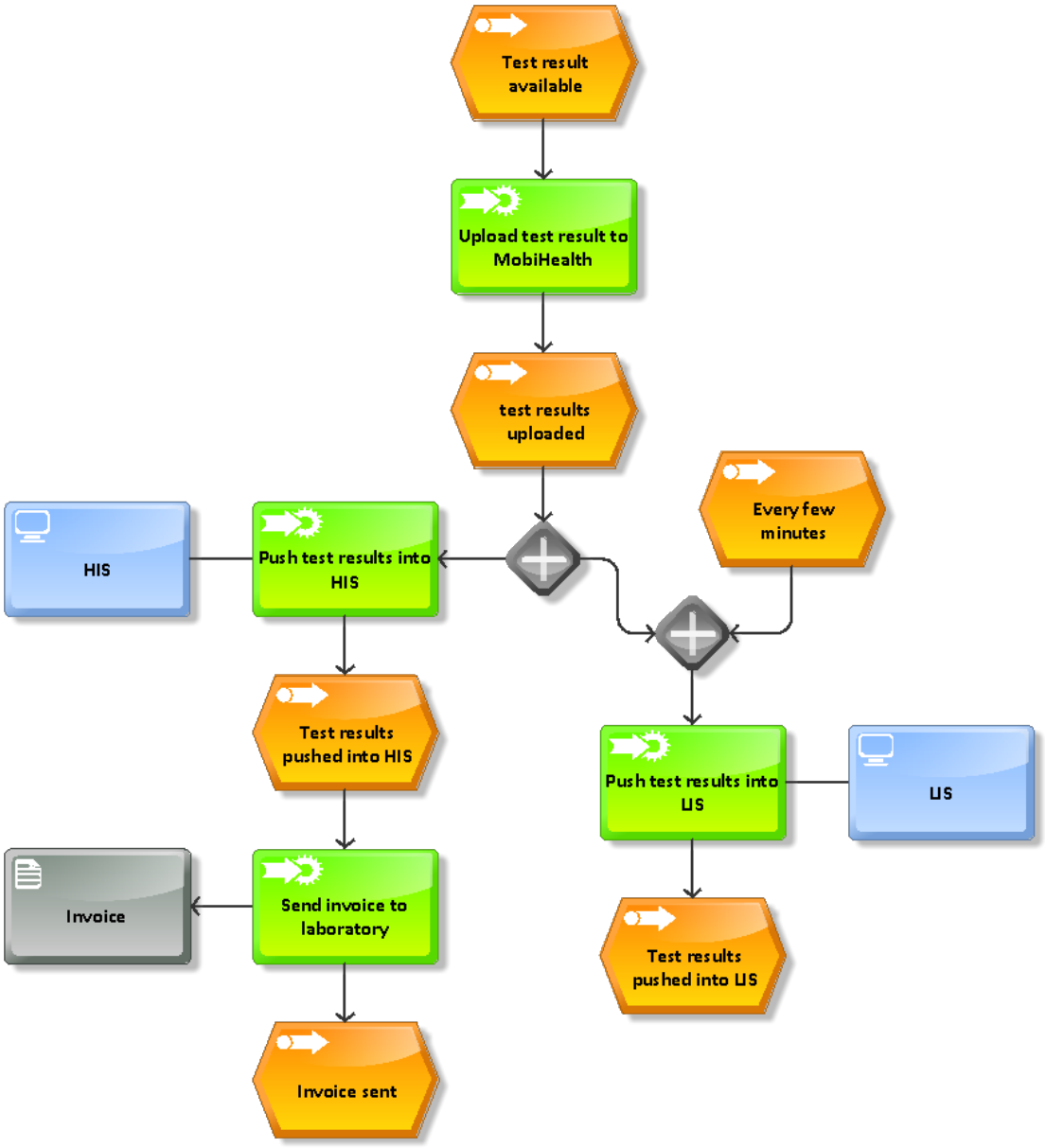


Figure C.8: Synchronisation process; used in $BM_{\beta}^{To\ be_2}$

D. Business models

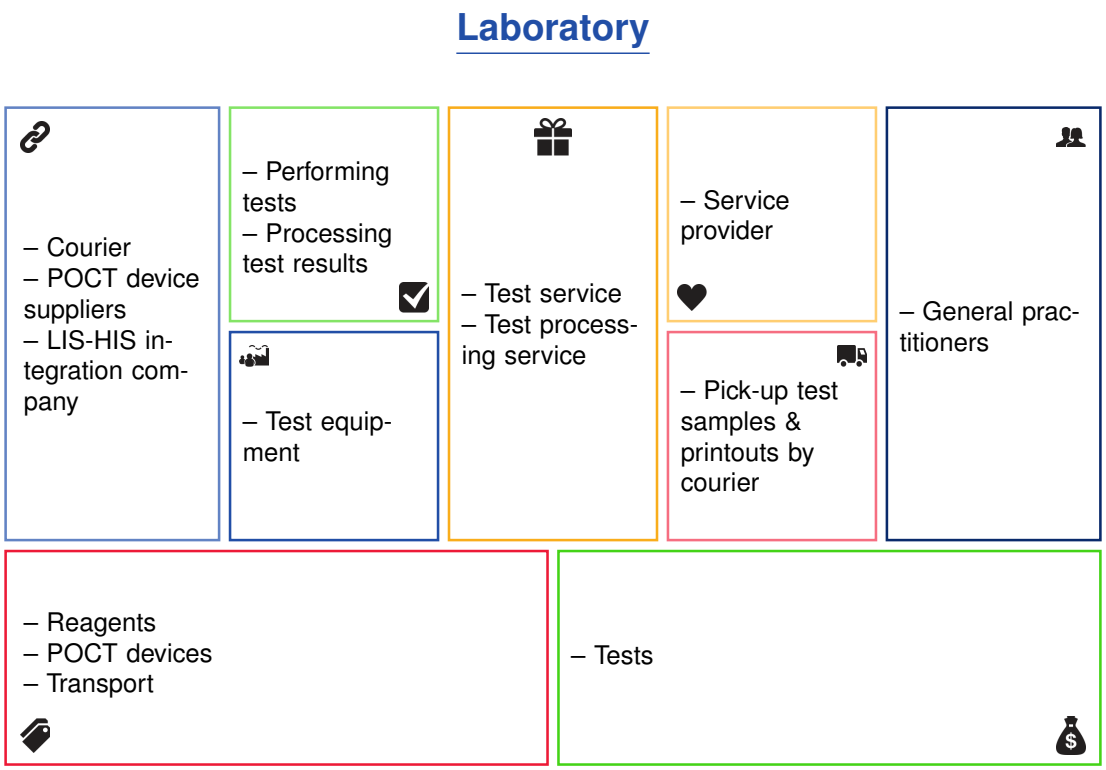


Figure D.1: Business Model Canvas [42] for $BM_{\alpha}^{As\ is}$; Laboratory perspective (Section 6.2)

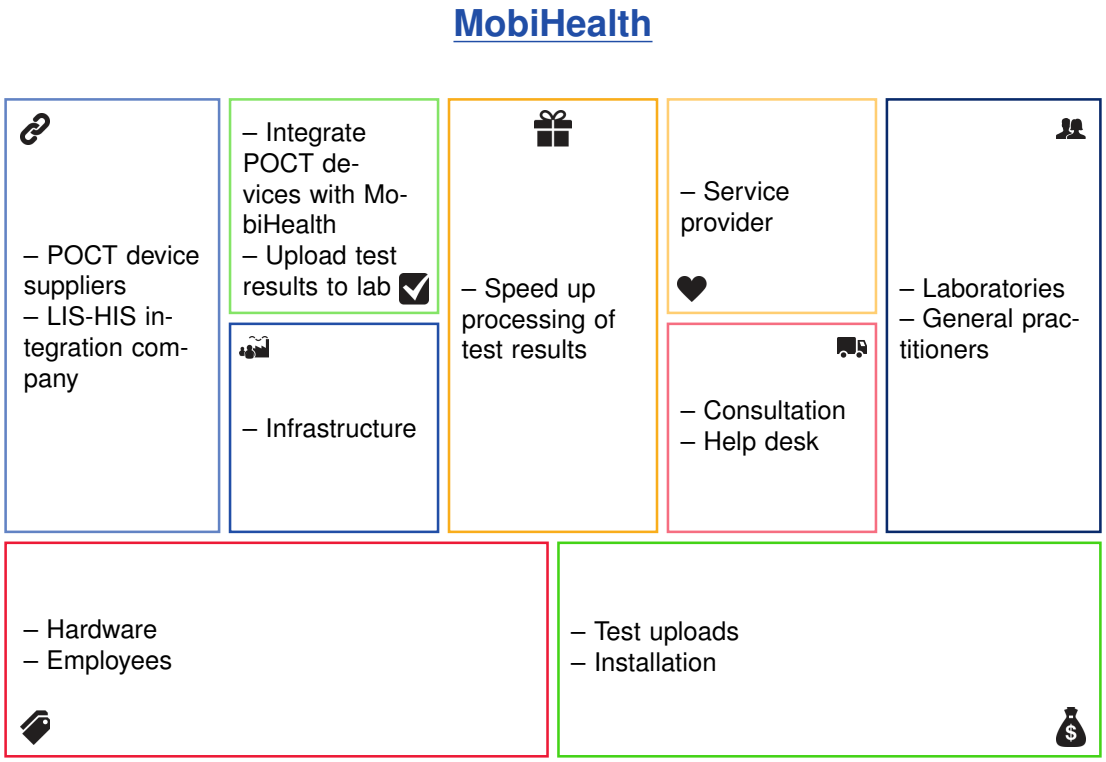


Figure D.2: Business Model Canvas [42] for $BM_{\alpha}^{As\ is}$; MobiHealth perspective (Section 6.3)

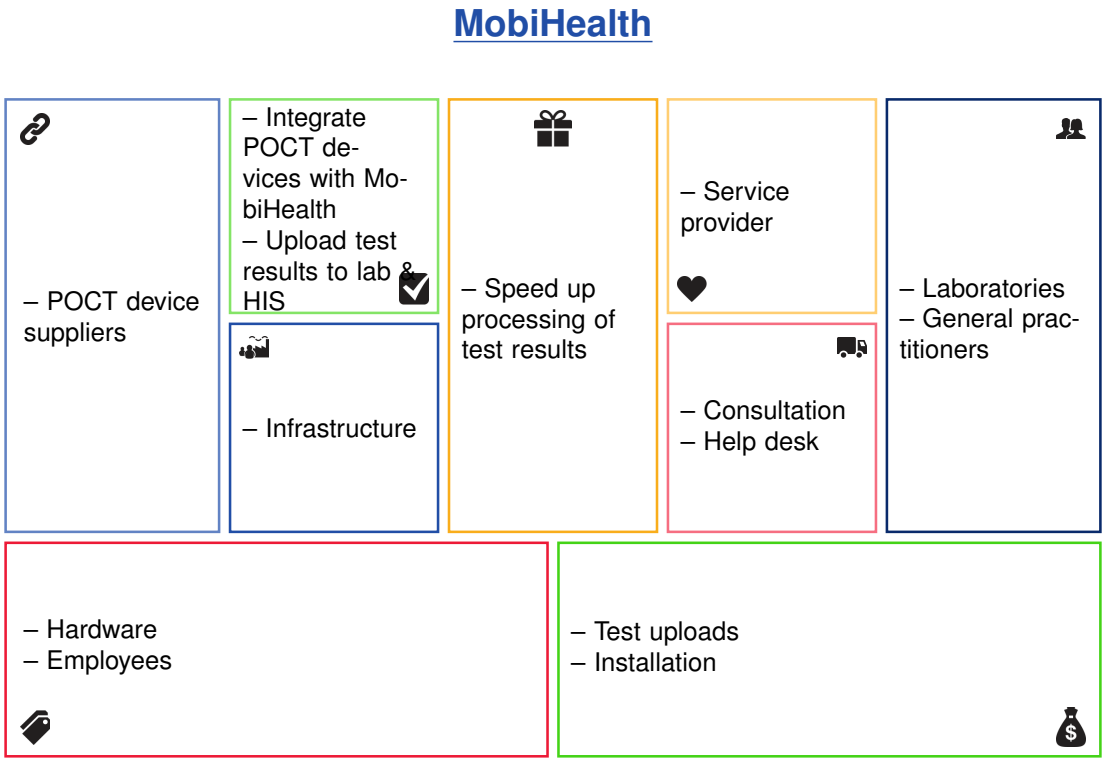


Figure D.3: Business Model Canvas [42] for $BM_{\alpha}^{\text{To be}_2}$; MobiHealth perspective (Section 6.4)

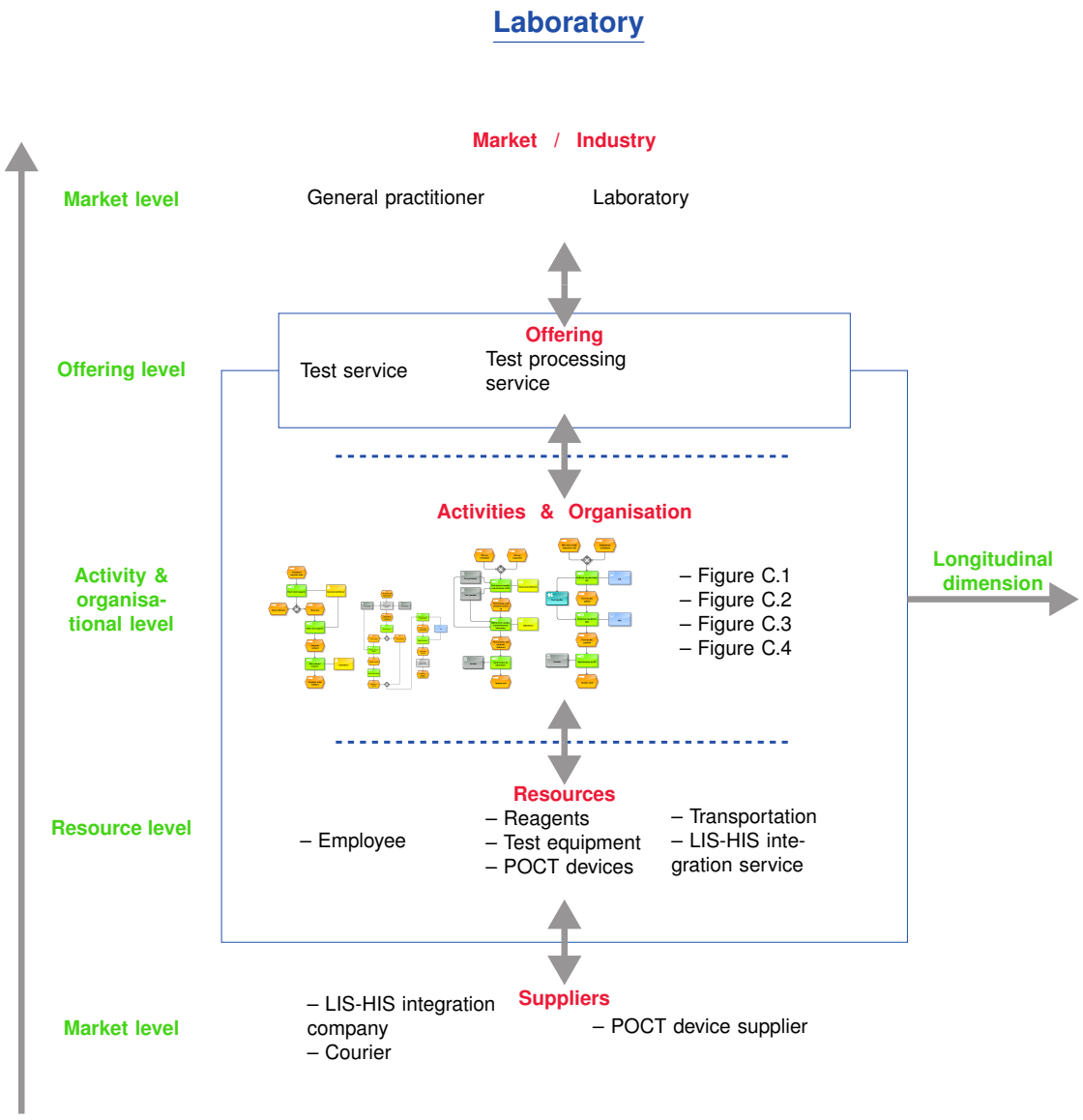


Figure D.4: Business Model Concept [26] for $BM_{\beta}^{As\ is}$; Laboratory perspective (Section 6.2)

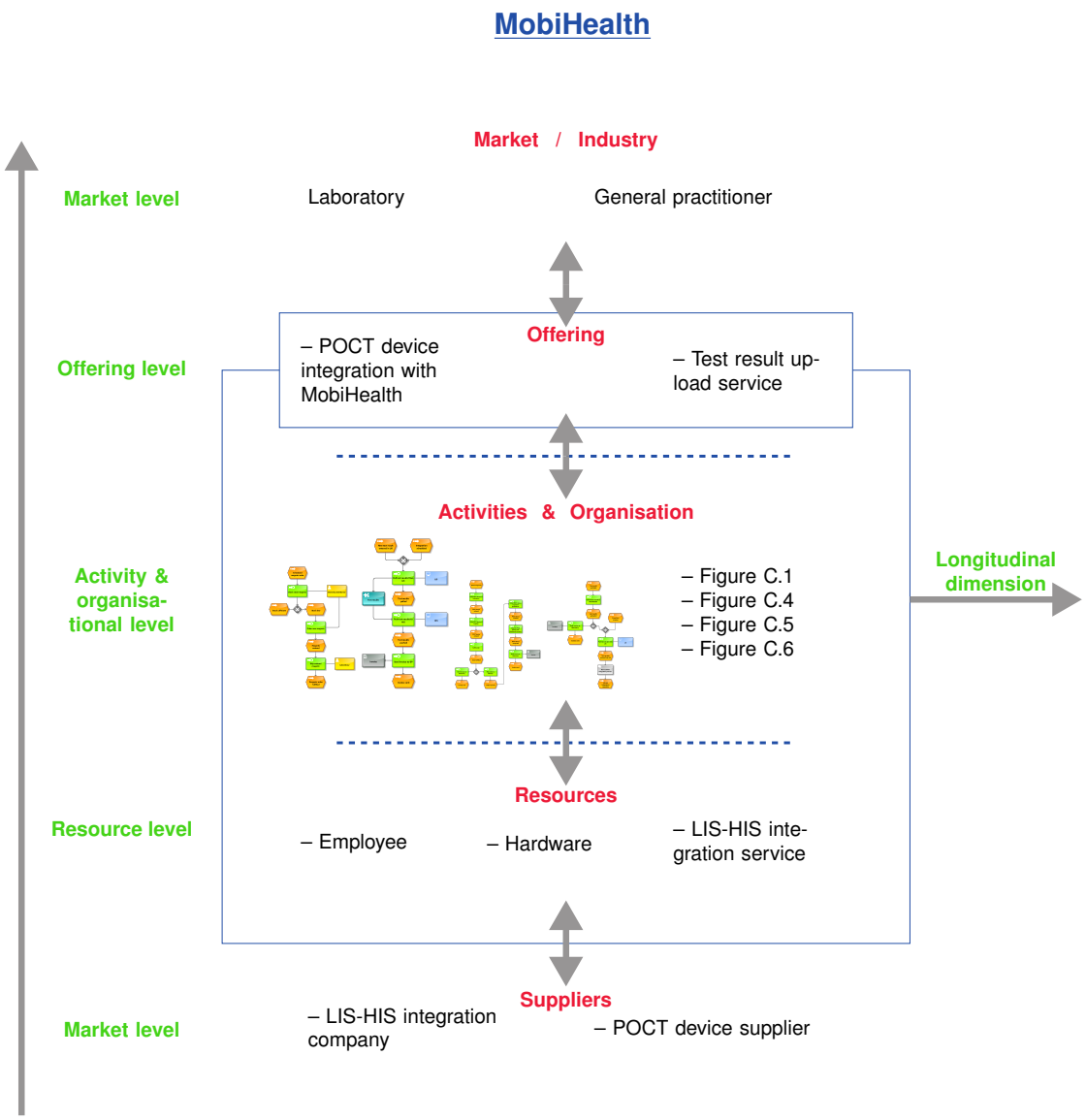


Figure D.5: Business Model Concept [26] for $BM_{\beta}^{\text{To be}_1}$; MobiHealth perspective (Section 6.3)

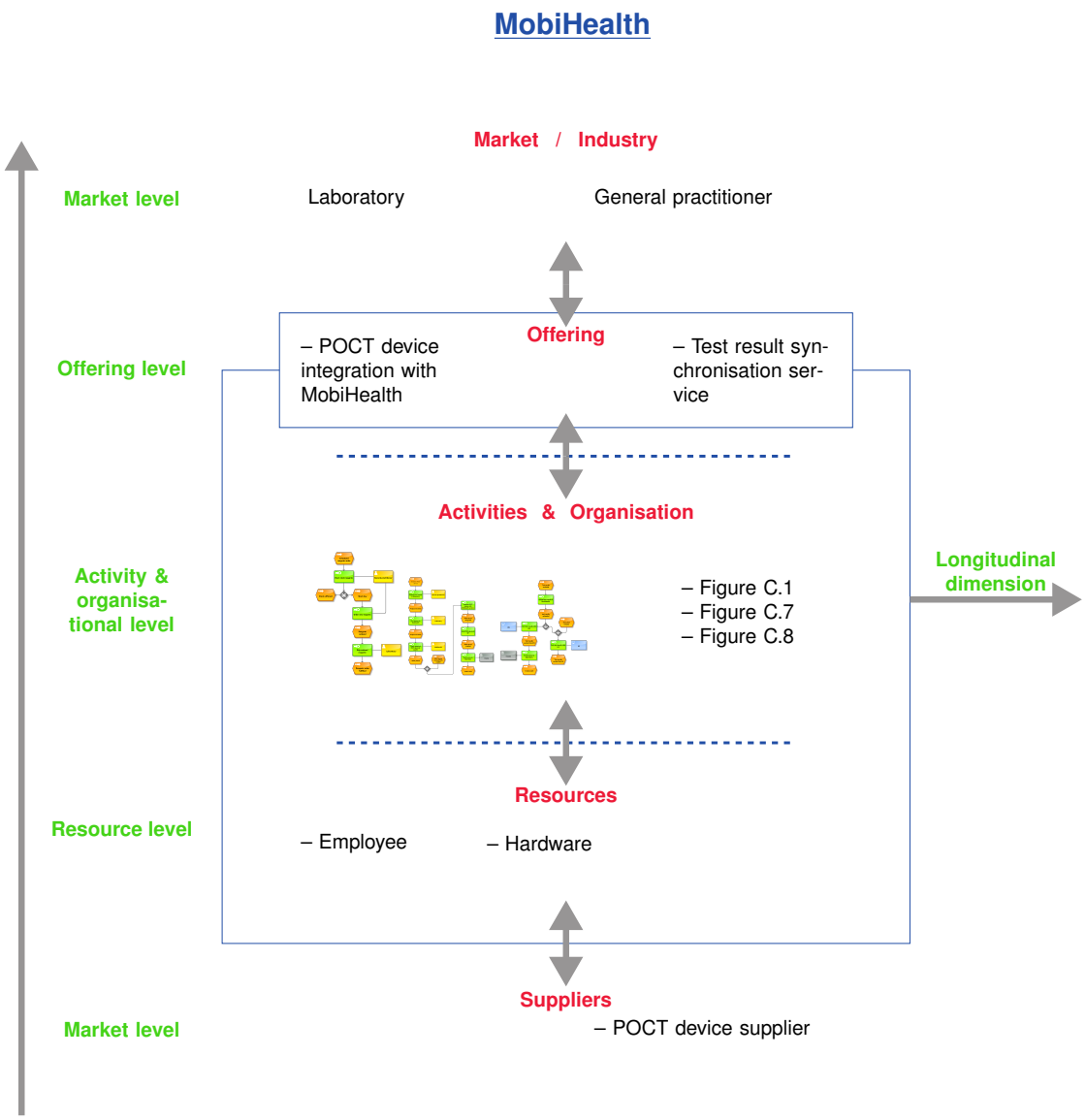


Figure D.6: Business Model Concept [26] for $BM_{\beta}^{To\ be_2}$; MobiHealth perspective (Section 6.5)