Assessing the potential of business model innovation for investment goods through Life Cycle Costing

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Abstract

In light of increasing competitive pressure, many manufacturers of investment goods are growing aware of the importance of business model innovation. Alternative business models that put more emphasis on the service content of the value proposition are gaining ground across many sectors. Manufacturers often face the challenge to identify the business model with the greatest earning potential. This paper demonstrates that Life Cycle Costing can be used to identify and quantify the potential for business model innovation. The relevance of this approach is illustrated with the findings of eighteen in-depth interviews with executives of Belgian industrial companies.

Keywords

Product Service Systems, Business Model, Life Cycle Costing

1 INTRODUCTION

European manufacturers can no longer rely exclusively on technological innovation to keep ahead of ever fiercer global competition. The importance of business model innovation is widely recognized by academia and practitioners alike. A 2005 survey by the Economist Intelligence Unit highlighted that more than half of 4,000 global executives believes business model innovation to be of higher importance for the competitive advantage of their company than innovation in products or services [1]. A survey among CEO's carried out by IBM in 2008 reported that two thirds of them are implementing extensive innovations in their business model [2]. Wilson De Pril, director-general of Agoria Flanders, Belgium's largest employers' organization and trade association, confirms the increasing importance of business model innovation for European industrial companies: "The lead that our companies have due to innovation in products and production processes is becoming smaller and smaller. That's why it is of the highest importance to implement complex forms of innovation that are difficult to copy. This can only be done by finding new ways of value creation, and this is where business model innovation comes into sight."

For manufacturers of investment goods (i.e. means of production) there is a trend towards business models that put more emphasis on the service content of the customer value proposition as opposed to a traditional, 'product-centric' business model. This leads to the development of Product-Service Systems (PSS), business models combining tangible products with intangible services to deliver value in use. In a PSS, the focus shifts from sales of the product towards sales of the use or result of the product. The most cited examples in this context are Xerox Corporation, which offers a price per copied page instead of selling copying machines and Rolls-Royce plc, which offers a "power-by-the-hour" contract under which airlines are charged a fixed fee per flying hour of an aircraft engine. Another example can be found in Belgium, where the company Arcomet has transformed itself from a small producer of construction cranes into the biggest independent construction crane rental company in the world. Over the last fifteen years the share of services in Arcomet's total turnover has increased from 20% to 95%. Between 2000 and 2007 its turnover more than doubled and its EBITDA almost tripled.

These examples are indicative of the huge earnings potential of business model innovation. Indeed, in the words of Johnson: 'business model innovations have reshaped entire industries and redistributed billions of dollars of value' [3]. But for most companies it is not evident to assess what the potential impact on profitability of an alternative business model is. Especially for companies that are traditionally organized around the delivery of products, the transition towards a PSS business model encompasses uncertain benefits and costs that are difficult to forecast.

Apart from the vagueness surrounding the term 'business model' itself, which is reflected in diverging definitions in the specialized literature, there is a clear lack of quantitative techniques to support business model innovation decisions. The goal of this article is to present the rough outline of a decision support method to assess the potential of a Product Service System for developers of investment goods, based on a Life Cycle Costing analysis of the technological infrastructure that delivers the customer value. An overview of the relevant literature on business models and PSS is presented in Section 2. Section 3 provides a short overview of Life Cycle Costing, followed by the main findings of eighteen in-depth interviews with executives of Belgian industrial companies. The relevance of LCC within the context of business modeling is illustrated with industrial examples. Finally an LCC-based method to identify the potential for business model innovation for investment good manufacturers is presented.

2 RELEVANT LITERATURE ON BUSINESS MODELS AND PSS

2.1 Introduction

The scientific literature on business modeling has mainly developed out of an interest in eBusiness models, related to the rise of the internet [4]. Therefore, most business model research has concentrated on business models for ICT services and systems. However, several constructs developed within the existing literature on eBusiness models are also useful for manufacturers of investment goods. In this Section those constructs and techniques will be presented. The focus will be on definitions of the term business model (Section 2.2), on the atomic elements of business models and the link with PSS (Section 2.3), on the design parameters of business models (Section 2.4) and on evaluation methods of business models (Section 2.5).

2.2 What is a 'business model'?

There is no universally accepted definition of a 'business model'. During the internet boom at the end of the 90s 'business model' became a buzzword that 'could be invoked to glorify all manner of half-baked plans' [5]. This explains the skepticism evident from Michael Porter's 2001 comment that 'the business model approach to management becomes an invitation for faulty thinking and self-delusion' [6]. Although Porter certainly had a point when condemning the lack of clarity surrounding the term 'business model', few researchers have followed his suggestion to dispose of it altogether. Business model research survived the 'dot com crash' and gained particular momentum over the past decade because – as Magretta notes – 'the experience of companies like Dell and Wal-Mart shows that [business models] are concepts of enormous practical value' [5].

Then what can be understood under the term 'business model'? It is not within the scope of this paper to discuss all the definitions that can be found in the literature (for an overview see [7] and [8]). Only a brief summary of the most important aspects that are necessary to understand the way the term 'business model' is used throughout this article is presented here:

1 Linder and Cantrell defined a business model as 'the organization's core logic for creating value' [9]. The notion of 'value creation' is probably the greatest common factor in all definitions. But other definitions emphasize the creation as well as the capture of value [10, 11]. The capture of value, referring to a conversion mechanism of a business idea into a sustainable profit, is essential in any successful business model [12]. Thus a business model is essentially '**a company's core logic for the creation and capture of value.'**

2 Many authors emphasize the **multidimensionality** of a business model, leading to more elaborate definitions, such as Osterwalder's [13]: 'A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams.' The view that a business model consists of several elements or levels appears in many definitions (e.g. [10], [14], [15]). A specific set of the constituting elements of a business model will be elaborated in Section 2.3.

3 As several authors observe, a business model **transcends the boundaries of one company**. Amit and Zott even make this multi-firm view the central idea in their definition of a business model: '[A business model] elucidates how an enterprise works with those external stakeholders with whom it engages in economic exchanges in order to create value for all involved parties' [16]. As Brandenburger and Stuart noted, value creation is an inherently cooperative process, while value capture is inherently competitive [17].

4 Among researchers there are differing views on the link between the business model of a company on the one hand and its strategy and business processes on the other hand. Only one approach is mentioned here, that views a business model as the translation of 'the strategy of a company into a blueprint of the company's logic of earning money' [18], thus viewing the business model level as an **intermediary level between the strategy and the business process level** in a company's management structure.

Summarizing, the **basic characteristics of a business model** are:

- It describes the way value is created and captured.
- It can be decomposed into several elements.
- It transcends the boundaries of one company.
- It forms an intermediary level between the strategic and the business process level within a company's management structure.

2.3 Elements of a business model and the link with PSS

Most recent business modeling research has focused on the decomposition of a business model into its 'atomic' elements [19]. Only one decomposition is mentioned here out of a multitude of approaches (for an overview see [19] and [20]). According to this approach, a business model consists of 4 basic elements:

1 The **customer value proposition:** the benefits delivered through products and/or services by the vendor to the customer in return for the customer's associated payment.

2 The **value network:** all actors that are involved in the creation and capture of value.

3 The **technological infrastructure:** the technical components, used for value creation, that generate costs.

4 The **revenue model:** the description of the formal relations within the value network, defining how revenues and costs are divided between the different actors.

Ballon and Arbanowski proposed a visualization of this decomposition into four elements (cfr. Figure 1), with an explicit indication of the way these elements are connected [10].

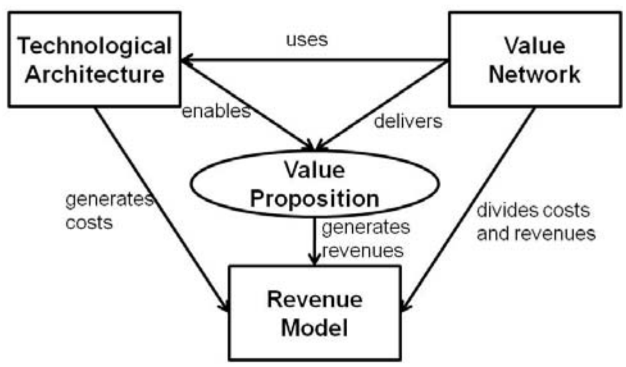

Figure 1: Basic elements of a business model [10].

These elements are not independent but provide four complexly intertwined levels on which a business model can be analyzed. Each level enables a complementary analysis of the business model.

Tukker clarified the link between 'product-service systems' and the terminology of business model research. He sees a 'product-service (PS)' as a particular value proposition, ‘that consists of a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs’ [21]. A ‘Product-Service System’ (PSS) on the other hand consists of the PS, the value network, the technological architecture and the revenue model [21], thus containing all the elements of a business model. According to these definitions, a **PS is a specific type of value proposition** and a **PSS is a specific type of business model.** Throughout the PSS-literature, the terms PS and PSS are not always used consistently. For example in the state of the art article of reference [22], a PSS is defined as ‘an integrated product and service offering that delivers value in use’, a definition that is more suitable for a PS. Throughout the remainder of this text, a PSS will be understood as a specific type of business model and the classification of a PSS in three basic types, product-oriented (type 1), use-oriented (type 2) and result-oriented (type 3) found throughout the PSS literature, will be adopted.

2.4 Design parameters of business models

A set of design parameters can be assigned to each of the atomic elements of a business model, that were introduced in the previous paragraph. In the business modeling literature several authors have proposed theoretical frameworks of business model design parameters (e.g. [4], [8]). The combination of these parameters aims to provide a complete and unambiguous characterization of the business model in question. The most comprehensive framework is provided by Ballon [4], but the fact that most of his parameters are rather high-level and specifically designed for ICT systems and services limits the applicability of his framework for investment goods.

Lay, Schroeter and Biege [23] have proposed a typology of ‘business concepts’ for manufacturing industries on the basis of a set of parameters found throughout the diverse literature relating to ‘new service-based business concepts’ (e.g. PSS, performance based contracting, full service contracts, etc.). Their parameters are arranged in a morphological box according to several options. The focus is on parameters concerning ownership and payment options. The fact that this framework is grounded in practice and specifically designed for manufacturing companies increases its applicability. But the set of provided parameters and options lacks comprehensive-ness. Especially parameters related to the specification of the value network and the technological infrastructure are missing. This incompleteness can mainly be attributed to the fact that the term ‘business concept’ is vaguely introduced and seems less comprehensive than the term ‘business model.’

2.5 Evaluation methods of business models

Pateli and Giaglis identified the development of business model evaluation methods as a ‘less mature’ sub-domain of business model research, concerned with the assessment of the **feasibility** and **profitability** of business models [20].

The **feasibility** of a business model is, according to Bouwman, determined by the ‘fit’ between the different business model design parameters [8]. Ballon speaks of a ‘strategic alignment’ between design parameters in order to be able to speak of a feasible business model [4]. Feasibility assessment requires a qualitative approach.

Assessment of the **profitability** of a business model requires a quantitative approach. For an alternative business model, benefits vs. costs and risks need to be determined in order to calculate the expected profit potential.

Few relevant profitability evaluation methods exist. Gordijn introduced the e3-value method to assess the profitability of Ebusiness models [24]. Representation methods of value networks introduced in his e3-value ontology [25] will be applied for investment goods in Section 4.

3 LIFE CYCLE COSTING AND ITS USE FOR BUSINESS MODEL INNOVATION

3.1 Introduction

In this Section the applicability of LCC within the context of business model innovation for investment goods is illustrated. In Section 3.2 a brief state of the art of LCC is provided, based on a literature study. In Section 3.3 the link between LCC and business model innovation is discussed and illustrated with industrial examples. Eighteen in-depth interviews with executives of Belgian manufacturers of investment goods were performed during the summer of 2009. The main topic during the interviews was the experience these companies had with Life Cycle Costing and their vision on the link between the LCC of their products and the opportunities of an alternative business model such as a PSS. In Table 1 the companies that participated in the interviews are listed.

	Type of product	**Interviewee job title**	**Company size**
A	Compressors	Sales Manager	large
B	Production machines	R&D manager	large
C	Transport systems	Project Leader R&D	large
D	Elevators	Business Unit Manager	SME
E	Gear boxes	R&D manager	large
F	Production machines	Service Manager	large
G	Insulation panels	R&D manager	SME
H	Production machines	Service Manager	large
I	Printing equipment	R&D manager	large
J	Telecom equipment	R&D manager	large
K	Robotics	CEO	SME
L	Packaging machines	CEO	SME
M	Egg incubators	Service Manager	SME
N	Weaving machines	Project Leader R&D	large
O	Switch panels	R&D manager	SME
P	Fire safety systems	CEO	SME
Q	Traffic control systems	R&D manager	SME
R	Weaving machines	R&D manager	large

Table 1: Characteristics of the 18 companies that participated in the interviews.

In Section 3.4 a method to identify and quantify the cost reduction potential of an alternative business model is presented.

3.2 State of the art of Life Cycle Costing

Life Cycle Costing is a method to quantify resources a product consumes over its complete life cycle in monetary terms. The Product Life Cycle (PLC) includes four phases design, production, use and end-of-life (EOL) [26]. LCC was introduced in the 1960’s in the U.S. Department of Defense to support purchase decisions of weapon systems. Over the last decades LCC has been methodologically well developed and used extensively in the military and construction sector [27]. In other industries, several authors observe the limited uptake of LCC and similar methods such as Total Cost of Ownership (TCO) [28-30]. Korpi and Ala-Risku performed an extensive review of LCC case studies published in academic and practitioner literature [31]. They conclude that most reported applications were 'far from ideal', assessing costs only from a limited number of PLC phases and using a deterministic approach in half of the cases, although throughout the literature a stochastic analysis is deemed essential in order to cope with the inherent uncertainties and risks when forecasting costs [32, 33].

The main purposes of LCC analyses are [34]:

- **Affordability studies** aimed at the quantification of the impact of the LCC of a system on long term budgets.
- **Supplier selection and evaluation studies** aimed at supporting choices between competing offers.
- **Design studies** aimed at identifying and influencing design aspects of products that directly impact LCC.
- **Repair level analyses** aimed at quantifying maintenance demands and costs.
- **Sales argumentations** aimed at informing customers of the LCC of products.

The financial metric used in an LCC analysis is preferably the Net Present Value (NPV). NPV allows to calculate costs in their present worth, taking the time value of money into account. A crucial parameter in the NPV formula is the discount rate, which determines the balancing of costs that occur now and in the future. A popular choice for a discount rate is the company's Weighted Average Cost of Capital (WACC); the rate that the company is expected to pay on average to its providers of capital.

Each cost component can be quantified by applying a cost estimation method. Such methods could be intuitive, analogical, parametric or analytic (see [35]). The analytic method that often succeeds best in capturing the causal relations between cost drivers and costs is Activity Based Costing.

Costs can be categorized in several ways:

1. A hierarchical categorization according to the life cycle phase. A Cost Breakdown Structure can be built up in a tree (see for example Figure 2). Each node is split into sub-nodes.

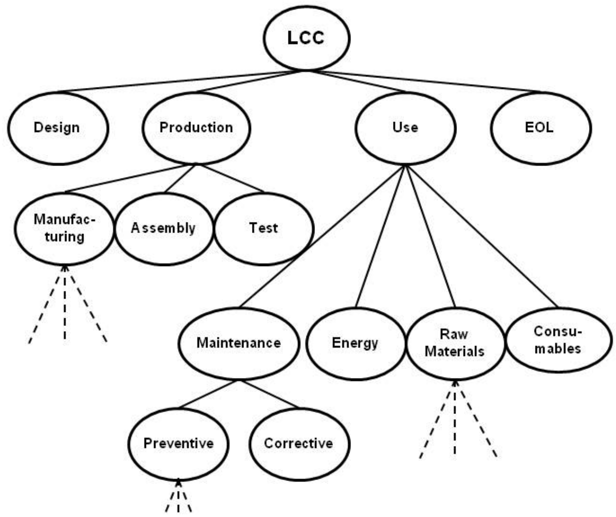

Figure 2: Cost breakdown in a tree structure.

2. A categorization according to the degree of quantification difficulty (cfr. [33]). Based on Emblemsvag's classification scheme, the following categorization will be used:
    - **Usual costs**: these are costs that can be traced directly (e.g. direct labor, supplies, energy, materials).
    - **Hidden costs**: these are usually lumped in the overhead in traditional cost accounting systems and are more difficult to trace (e.g. reporting, inspection, planning).
    - **Liabilities**: these are costs that arise due to non-compliance and potential future liabilities (e.g. liabilities from customer injury, penalties and fines)
    - **Opportunity costs**: these 'costs' are not a cost in the sense of a consumption of resources but reflect the minimum of the lost revenue due to non-performance and the cost of the best available alternative (e.g. quality loss, missed output). See 3.3 for examples.

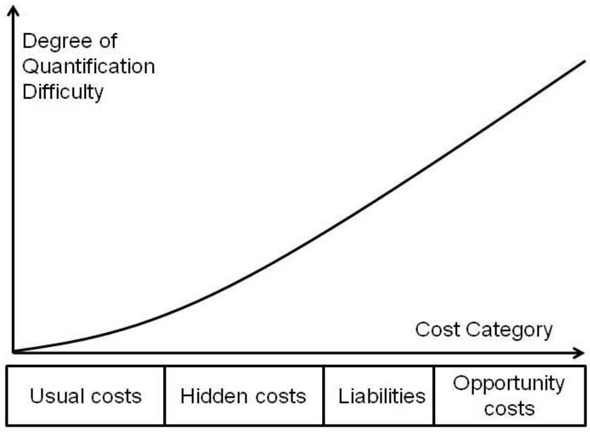

Figure 3: Cost categorization according to the difficulty of quantifying costs (based on [33]).

Both classifications can be combined in a simplified conceptual model, presented in Figure 4. Four concentric ellipses indicate the cost categories according to quantification difficulty. The quadrants in the scheme indicate the life cycle phases.

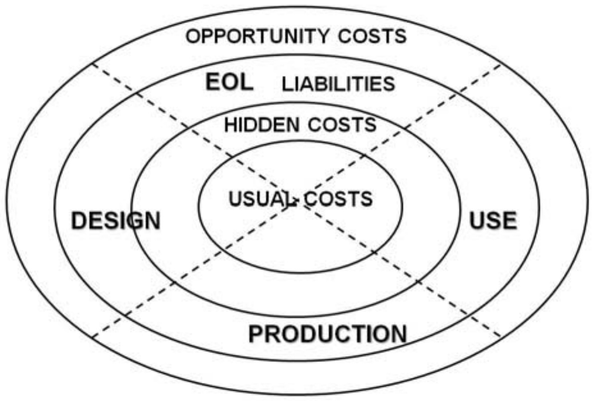

Figure 4: Combination of both categorizations in a simplified model.

3.3 LCC within the business model framework and industrial examples

In this Section the applicability of Life Cycle Costing within the framework provided by the 'business model' construct is discussed. Specifically for manufacturers of investment goods, LCC can be employed to identify the potential of an alternative business model such as a use- or result-oriented PSS, adding one more possible purpose of an LCC analysis to the list of Section 3.2.

The rationale behind applying LCC in this context is that often there is an 'untapped LCC reduction potential', that could be realized in a new business model. Within a business model, an LCC analysis is performed at the level of the technological infrastructure. The focal point of the analysis is the investment good, but the business model framework allows extending the horizon of analysis towards other technological systems that are interacting with the main system.

What the 'untapped LCC potential' means in practice will be clarified with examples of successful business model innovations.

- Xerox, probably the most cited example in this context, reports on its website that through reuse of remanufactured components, each year 'hundreds of millions of dollars' are saved. In its 'pay per copy' business model Xerox retains ownership of its products and thus has a guaranteed delivery of reusable components. The untapped LCC reduction in the End-Of-Life phase was only realized after the new business model had been adopted.
- Arcomet, the Belgian crane rental company, developed a type of construction cranes, with an on-site assembly and disassembly time of only 15 minutes. This untapped LCC potential in the use phase is captured by Arcomet itself, as it performs these operations in its rental business model.

These examples make clear that the potential of a use-oriented or result-oriented PSS can be made visible by quantifying the 'untapped LCC potential' of the technological infrastructure used to deliver value within the business model. Often the manufacturer's business model does not provide the right incentives to optimize the design of its products over their complete life cycle. Competitive pressure forces the manufacturers to make design choices that are not LCC-optimal.

During the interviews most respondents confirmed the existence of an 'untapped LCC potential.' Ten out of eighteen answered this potential is certain and substantial for their products.

Some interesting conclusions can be drawn from their comments on this question:

- Seven out of ten respondents indicate that a potential LCC reduction exists because market conditions pressure them to reduce the sales price of their product, rather than the complete LCC. Company O for example, an SME manufacturing switch panels for industrial customers, notes that most of its clients are not concerned with the energy usage of its products, although the energy cost over the lifetime of a switch panel (typically twenty years) is a multiple of the initial investment cost. As a result most of their products are not designed with the best available technology, but with cheaper, less energy efficient components.
- Several companies see a substantial LCC-reduction possibility in external systems interfaced to their product or system that can be realized by adapting the design of their product. Company D for example noticed a cost saving potential that could be realized if heat losses through the elevator shaft were taken into account during the design of an elevator. Company P noticed important LCC reductions possible in many external systems interfaced to their fire safety systems (cfr. Section 3.4).

In a next question, the company representatives were asked to specify what they assumed to be the predominant factor of the LCC for their customers. It was remarkable that six respondents indicated that the 'cost of non-performance' is always dominant. Four more indicated that for some customer segments it is dominant. The 'cost of non-performance' is actually not a cost in the true sense of the word. It is not a consumption of resources, but the missed revenues due to product malfunctioning accumulated over the lifetime of the product. High variability from customer to customer was mentioned by twelve respondents as an inherent attribute of this missed revenue. Some examples:

- If a weaving machine (companies N and R) is not preset correctly it produces 'second choice' fabrics, salable at lower market prices. Accumulated over the life time of a weaving machine this lost revenue is quite substantial.
- Company M manufactures egg incubators to poultry farms. The hatching process yield depends on complex interaction of parameters such as the temperature, the humidity, the air quality and the risk that eggs are damaged during transport. The cumulative value of eggs that are not hatched over the life time represents a substantial lost revenue.
- Two companies (A and J) noticed that their customers often insure themselves against the cost due to product malfunctioning by installing redundant capacity. This confirms that the opportunity cost is bounded from above by the cost to provide a backup.

The last question was whether the respondents saw an evolution towards a use- or result-oriented PSS for (some of) their products.

- Three companies (A, C and P) indicate that they already have a PSS type 2 or 3 operational for some customer segments. Company A delivers compressed air per m³ to some customers, company C offers a transport service per km and company P offers total protection solutions.
- Two companies are developing a PSS type 2 or 3 and will introduce it to the market within one year.
- Nine companies regard a PSS type 2 or 3 as a possibility for the near future (within five years).
- Three companies do not regard a PSS type 2 or 3 as a realistic business model for the near future. Two of these companies develop subsystems of an investment good.

This extensive case-based research clarifies that out of this sample of eighteen companies, the majority notices an evolution towards PSS type 2 or 3 business models and that majority sees an untapped LCC potential that could be realized in another a PSS type 2 or 3.

3.4 LCC based method to identify the potential of an alternative business model

The potential of an alternative business model can be identified by an LCC based method, passing through the following steps:

<u>Step 1:</u> Map the **technological infrastructure** of the current business model in terms of:

- all subsystems forming part of the investment good
- all external systems that are networked to the product either physically or electronically over the life cycle of the investment good

As an example, a fire safety system can be decomposed in subsystems as demonstrated in Figure 5. A non-comprehensive overview of external systems that are networked to the fire safety system are drawn in Figure 6.

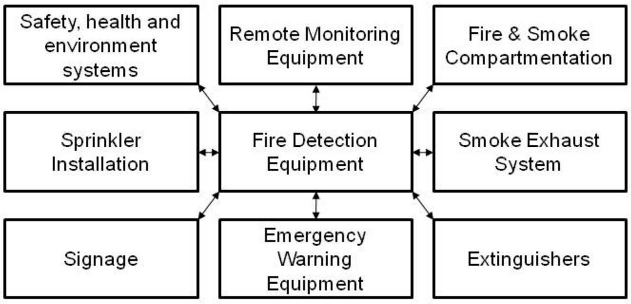

Figure 5: Technological infrastructure of a fire safety system.

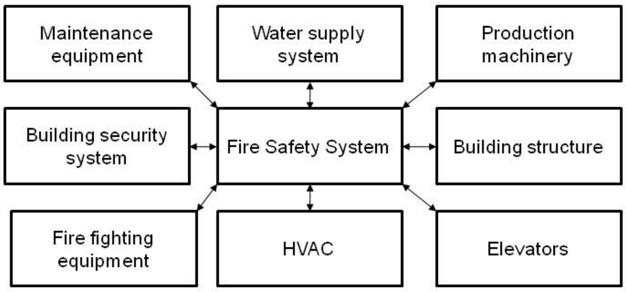

Figure 6: Some of the external systems interfaced to the fire safety system of a production facility.

Step 2: Map the **value network** of the business model, including all companies that create or capture value over the life cycle of the investment good.

In the eBusiness model literature several tools and methods exist for value network mapping. The approach demonstrated here is the e3-value™ ontology of Gordijn and Akkermans based on UML class diagrams [25]. In this representation, all actors are depicted, indicating the value objects (products, services or experiences) they exchange through value interfaces. A non-comprehensive value network for a fire safety system is provided in Figure 7 as an example.

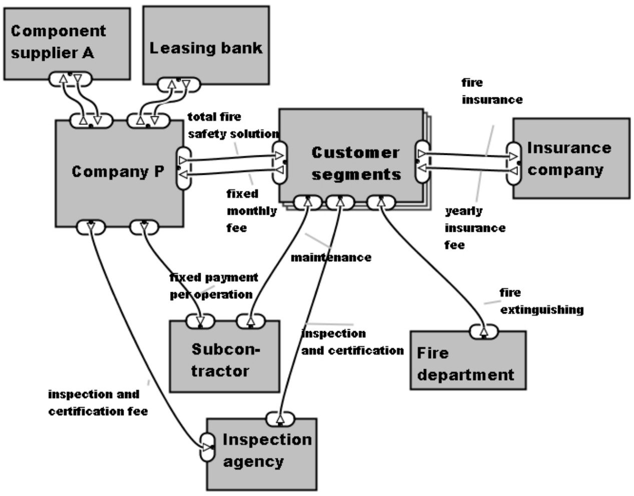

Figure 7: Simplified value network for a fire safety system business model, following the e3-value™ ontology [25].

Step 3: List the possible **LCC saving opportunities** over all actors of the value network in the technological infrastructure and its interacting systems. LCC reductions can be realized in three categories:

1. LCC reductions in subsystems realized through design modification of the investment good
2. LCC reductions in external systems realized through design modification of the investment good
3. LCC reductions in subsystems realized through design modification of external systems.

During this step all possible LCC reduction possibilities are listed. A first rough outline can be made by constructing the 'circles model' of Figure 4 for each actor of the value network. For a fire safety system, these are some examples of cost reductions in the three categories:

1. LCC reductions in subsystems realized through design modification of the fire safety system:
    - Sprinkler fitting costs (e.g. test and inspection) for the subcontractor that can be influenced through an adapted design of sprinkler nozzles.
    - Reduction of EOL costs by design for remanufacturability of sprinkler pipes
2. LCC reductions in external systems realized through design modification of the fire safety system:
    - Liabilities that arise when elevators are used during fire that can be prevented by controlling elevator access by the fire detection unit.
    - Lost production revenue for the customer due to false alarms, reducible by increasing the reliability of the fire safety system
3. LCC reductions in subsystems realized through design modification of external system:
    - LCC reductions possible in lifetime extension and reduced maintenance costs by controlling the water quality.
    - LCC reductions possible by using construction materials that require less cooling capacity of a sprinkler installation in case of fire.

Step 4: Identify **feasible business models** that capture the LCC saving opportunities of the previous step through changes in one or more design parameters of the business model.

Based on the LCC opportunities identified in the previous step, an inventory is made of business models that capture the cost saving potential. New business models can be constructed by changing one or more parameters within the four business model elements, for example:

- **Technological infrastructure**: extend the technological infrastructure with extra subsystems (e.g. integrate the building security system with the fire safety system)
- **Value network**: add or remove actors from the value network (e.g. extra subcontractor), implement a joint value creation (e.g. bundling of a fire safety system with a fire insurance)
- **Value proposition**: offer extra services (e.g. building structure design support for optimal fire safety), include other Critical To Value (CTV) attributes in the value proposition (e.g. reduce the ecological impact of operating the fire safety system)
- **Revenue model:** payment per availability, setting of contractual penalties (e.g. fixed fee for continuity of services)

In addition to these specific examples of design parameters per element, Table 2 presents a generic overview of design parameters of a business model. This framework is specifically designed for investment goods and partially inspired by the frameworks mentioned in Section 2.4.

Value proposition design parameters	
CTV attributes	Which attributes are critical to value to the customer and how are they reflected in the value proposition?
Customer involvement	How involved is the customer in the value creation process?
Product vs. service content	What is the relative importance of the product content vs. the service content in the value proposition?
Target customers	Which (segments of) customers are targeted by the business model?
Value network design parameters	
Actors involved	Which actors are involved in the value creation and capture? Does this change over the life cycle of the investment good?
Role of each actor	What is the role of each actor in the different life cycle phases of the investment good (design/ production/ use/ disposal)?
Customer access	Which actors of the value network have direct access to the customer or end user of the investment good?
Hierarchy	What are the hierarchical relationships among the actors of the value network?
Technological infrastructure design parameters	
Asset specificity	Which products and components are designed and used specifically in this business model?
Degree of modularity	How modular is the technical buildup of the investment good?
Product ownership	Which actor owns the investment good during the different product life cycle phases?
Interface with external systems	Which external systems are in which way interfaced to the product or system?
EOL recovery	Which material content is recovered during the End Of Life phase of the products through recycling, reuse or remanufacturing?
Revenue model design parameters	
Operational expenses	Which actor pays which operational expenses during the different life cycle phases?
Capital expenses	Which investments are carried by which actors during each phase of the life cycle?
Revenue model	How are the revenues divided among the actors of the value network? What is the transaction basis (e.g. payment per use, per result, per availability, per product)?
Risks	Which actor carries which risks during the different life cycle phases?

Table 2: Design parameters of a business model of an investment good

Inventorying possible new business models can be done by sweeping each parameter over its discrete or continuous set of possibilities. Only the feasible business models are retained. The evaluation of the feasibility of a business model will not be elaborated here; such a method would require a comprehensive, qualitative approach. In practice however, decision makers within the company for which the analysis is performed can eliminate most of the unfeasible business models easily, by using their knowledge of the market in which the company operates and by applying common sense.

> Step 5: Compare the feasible business models quantitatively through an LCC analysis. Choose the **optimal business model** out of the remaining alternatives.

Only for the feasible business model alternatives the profitability is assessed quantitatively. This encompasses first a high level analysis: modeling and simulating each cost component in detail is often unnecessary. Of interest are only the cost components that have a substantial contribution to the total LCC and those which are most susceptible to optimization. An iterative process can be followed that reduces the set of business model alternatives while raising the resolution of the LCC analysis.

An essential part of this step is the analysis of the uncertainties and risks involved. Methods that can be employed in this analysis are Monte Carlo simulations and scenario techniques, to generate ‘what-if’ analyses that aid the decision making process.

Choosing the ‘best’ business model out of the remaining alternatives can be supported with a Multi Criteria Decision Aid (MCDA) method. MCDA is a theoretically sound approach for making complex decisions with multiple decision makers and multiple criteria under uncertainty [36]. Development of an appropriate MCDA model that can aid business model innovation decisions will form the subject of further research.

4 SUMMARY

In this paper the relevance of Life Cycle Costing within the business model framework was demonstrated. The outline of a systematic method to identify and quantify the LCC reduction potential of an investment good within a new business model was presented. This kind of analysis can make the potential of a use- or result-oriented PSS visible, and can indicate opportunities for joint value creation, e.g. with manufacturers of external systems. The main advantages of combining the constructs of eBusiness modeling research with Life Cycle Costing is that the complex but important decisions regarding business model innovation can be quantitatively supported. Representation techniques of business models and a set of design parameters were presented.

The industrial relevance of the presented method is illustrated with the findings of eighteen in-depth interviews with executives of Belgian industrial companies. The majority of the interviewees notice an evolution towards PSS type 2 or 3 business models and confirm the existence of an untapped LCC potential that can be realized through business model innovation.

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