

# Proactive Cost Management: Integrating Use Phase Data to Reduce Uncertainty

**Julian Wilberg, Sebastian Maisenbacher, Udo Lindemann**

*Institute for Product Development, Technical University of Munich, Germany  
wilberg@pe.mw.tum.de*

## **Abstract**

Manufacturing firms need to develop products for competitive markets with a distinct cost-value-ratio in order to stay successful in the long run. Literature provides approaches such as Target Costing, Value Engineering, and Integrated Value Engineering. From a methodic standpoint support is available for cost management, but the approaches depend highly on the information input (e.g., customer needs, market situation). From a strategic standpoint cost management needs to be proactive because a reactive strategy is not successful and sustainable in highly dynamic and competitive markets. Companies are at the same time confronted with challenges that arise due to the advancing servitization and digitalization. Offering such products establishes a feedback loop, which provides the manufacturer with use phase data. The data is valuable for the cost management because it can help to reduce uncertainty and make better informed decisions. However, using such data for cost management requires an adjusted strategy for proactive cost management. This paper analyses the opportunities that use phase data offers for companies and proposes an initial and theoretical process that supports companies in developing a tailored strategy for their proactive cost management.

***Keywords: Proactive Cost Management, Integrated Value Engineering, Big Data***

## **1 Introduction**

Companies are facing high competitive pressure due to increased customer demands and international competition. Product development especially becomes an important factor because companies are required to shorten their product development cycle time, increase the product's quality, and improve the value (functionality-cost ratio) of their products. Controlling and managing the three dimensions of cost, quality, and functionality of the product must start early on (Cooper, 1995; Porter, 1980). Product design therefore needs to make a tradeoff between the three dimensions. Approaches like target costing (TC) and value engineering (VE) have been applied in industry in order to manage and shape the three dimensions (cost, quality, and functionality) during the product development process. The introduction of new cost management approaches like TC and VE was necessary because previous approaches failed to support companies in overcoming new challenges that arose due to a changing competitive environment (Ax, Greve, & Nilsson, 2008). In order to combine the benefits of both approaches within one, the Integrated Value Engineering (IVE) approach was

developed (Behncke, Maisenbacher, & Maurer, 2014). A major advantage of the IVE approach is that it allows to identify potential for value improvement on a requirements, functional, and components level (Maisenbacher, Behncke, & Lindemann, 2013), which allows for early cost management.

Approaches like TC, VE, or IVE exist to support companies with their cost management from a methodic perspective. However, not only approaches are required but also a suitable strategy. Research highlights that it is important to establish a proactive cost management strategy that aims for systematic, continuous, and sustainable cost management (Kajüter, 2000). Hence, cost management approaches must be embedded in a cost management strategy. To reach an anticipatory cost management strategy that avoids problems beforehand a few aspects are important. First of all, cost management should begin early on during product development because up to 70 to 80 percent of the final product costs are determined during the conceptual design phase (Ehrlenspiel & Meerkamm, 2013). Furthermore, engineering changes become more costly the later they are implemented (Pahl & Beitz, 1996). Secondly, informed decisions are crucial for successful cost management because uncertainty e.g., concerning customer requirements or product use leads to wrong decisions in product design (Ax et al., 2008; Zengin & Ada, 2010). Companies do not only face challenges from the cost management itself, but also concerning the products they need to offer and develop (Lucas & Goh, 2009). Companies are nowadays often required to offer Product-Service Systems (PSS) to become, or stay successful (Baines et al., 2007). At the same time digitalization allows companies to develop new products and reach competitive opportunities (Dellarocas, 2003). Offering such products provides companies with value data concerning the actual use of their products. Therefore, cost management also needs to adjust to take advantage of the new data sources in a systematic way.

The objective of this paper is to analyze the impact available use phase data has on cost management and to explore related opportunities. The paper presents an initial and theoretical approach to support companies in establishing a more data-driven, proactive cost management.

## **2 Theory of Cost Management**

### **2.1 Target Costing (TC)**

The TC approach focuses on market-driven profit planning during product development in order to ensure a future financial return (Ansari, Bell, & Okano, 2006). The basic idea of TC can be described with the following equation: Target Cost = Target Price – Desired Profit. The equation reveals that a company must manage two external variables because the market and the competitive situation determine the price and profit. The two external variables therefore constrain the development of products, and companies need to manage the product costs in order to offer a financially successful product. The case study with TC emphasizes that TC can lead to an increased profitability, customer satisfaction, and market share (Ibusuki & Kaminski, 2007). The TC approach consists of ten process steps, which help to determine the target cost of a product. The TC process covers all steps from the implementation of a new cost management philosophy to the evaluation of the achievements reached through TC. A detailed description is provided by Ibusuki and Kaminski (2007).

An important characteristic of the TC process is that it is a market-driven approach (Cooper & Slagmulder, 1999). The success of TC is determined by the acquisition of external

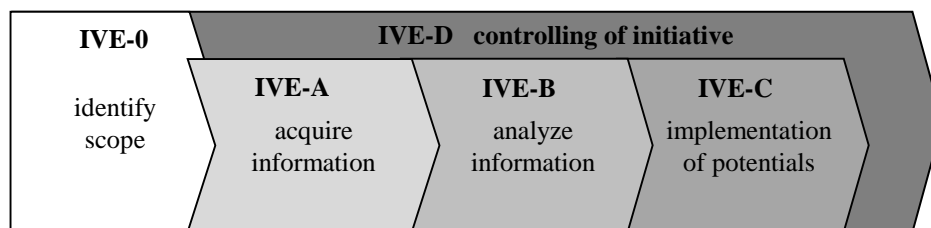
information concerning customer requirements or market prices (Ax et al., 2008). The mentioned information can be acquired until step TC-4 from external sources through e.g., interviews, customer surveys, and prototypes. The accuracy of information gained from the market and the customers is of great importance because it is used during the entire process.

## 2.2 Value Engineering (VE)

The second approach to discuss is VE because it breaks down products, processes, or services into functions (Fridholm, 1969). The main objective of VE is not to reduce cost, but to improve the value (Haskins, 2010). The value is the ratio between functionality and resources (cost) (Cooper & Slagmulder, 1997). For technical products the first step is to identify the functions each of the components is fulfilling (Cross, 2008). During the next step the costs for each functions is determined. The ideation phase searches for different opportunities to improve the value of the product. One possibility is to reduce the costs of one or more different functions without reducing the functionality of product. The second possibility is to increase the functionality without changing the cost. These are the two basic options for value engineering. The value optimization needs to be case specific and often requires that both the functionality and the costs are adjusted.

## 2.3 Integrated Value Engineering (IVE)

The IVE approach is relatively new (Behncke et al., 2014; Maisenbacher et al., 2013). The basic idea is to combine the benefits of TC and VE within a comprehensive approach, which was therefore called Integrated Value Engineering (IVE). The IVE approach combines all basic process steps of TC and VE, but the process model was also extended.



**Figure 1. Basic Process for the Application the IVE approach (Behncke et al., 2014)**

The basic approach considers three domains of a product: components, functions, and requirements. These three domains describe the concretization steps during product development and therefore allow the application apply the IVE approach throughout the entire product development process. The three domains are interlinked and the approach uses structural complexity management to model and describe the dependencies among the three domains. Figure 1 depicts the general process steps of the IVE approach. The starting point (IVE-0) is the definition of the objectives of the initiative. The process ends with an evaluation of the final results. A detailed description of the process is presented by Behncke et al. (2014).

Compared with other approaches, the IVE approach allows for a comparison of current costs and target costs also on a requirements and functional level, which makes it possible to identify and implement value improving measures on all three domains. Due to the fact that the IVE approach combines TC and VE, it also relies strongly on the information input concerning the product use, customer needs, and the market. An analysis on a requirements level can be carried out early during product development if the necessary information is available, which means that information is crucial for the application.

## **2.4 Proactive Cost Management**

The methodical support (e.g., TC, VE, or IVE) is one important factor for successful cost management. However, those approaches need to be part comprehensive and cooperate cost management strategy (Kajüter, 2000). According to Kajüter (2000) proactive cost management needs to fulfill the following requirements: market oriented, holistic, anticipatory, and continuous. The overall objective of this strategy is to prevent problems and enable continuous value optimization, which is more successful than reactive cost management.

Market orientation is an important aspect of the TC and IVE approaches. In order to have a holistic cost management, companies should not only consider production costs but also development and life-cycle costs. Anticipatory cost management means that product costs are planned early on in the development process. Other publications also highlight that cost management in general and TC in particular should start already in an early phase of the product development, which means the conceptual design phase (e.g., (Cooper & Slagmulder, 1999; Szeghő, Bercsey, & Eigner, 2008)). Cost management in early phases is important because the final product's costs are already determined during the conceptual design phase (Ehrlenspiel & Meerkamm, 2013). Therefore, information concerning the product, the customer needs, and the market is crucial in order to support better and more informed decisions during product development. However, the early phases of product development is characterized by uncertainty and complexity (Verganti, 1997). Overall, successful early cost management stands and falls with uncertainty concerning the environment and the product use. The fourth requirement is that cost management is continuous in order to be proactive. A company should aim to continuously improve the product's value and decrease the product's costs (Kajüter, 2000). Therefore, systemic learning from past experience is very important in order to continuously improve the cost management. The first two requirements for proactive cost management address aspects that are linked to the cost management approaches, whereas the third and fourth requirements are more strategic ones.

## **2.5 Challenges in Current Cost Management**

The two key enablers for successful cost management are an early integration and low uncertainty concerning the product, the customer needs, and the market. Both objectives are conflicting because uncertainty decrease over the course of the product development process, which is contradictory to proactive cost management (Verganti, 1997). The IVE approach especially addresses this issue by decomposing the product into the three product domains: requirements, functions, and components. The application of this approach can start earlier on during product development. However, cost management during product development not only faces challenges that arise directly from the design of the approaches but also from the product development environment itself. Nowadays, the present challenges in product development are shorter product development cycles as well as multidisciplinary and complex products (Hobday, 2000). Therefore, cost management becomes more challenging and requires the involvement of different disciplines at the same time.

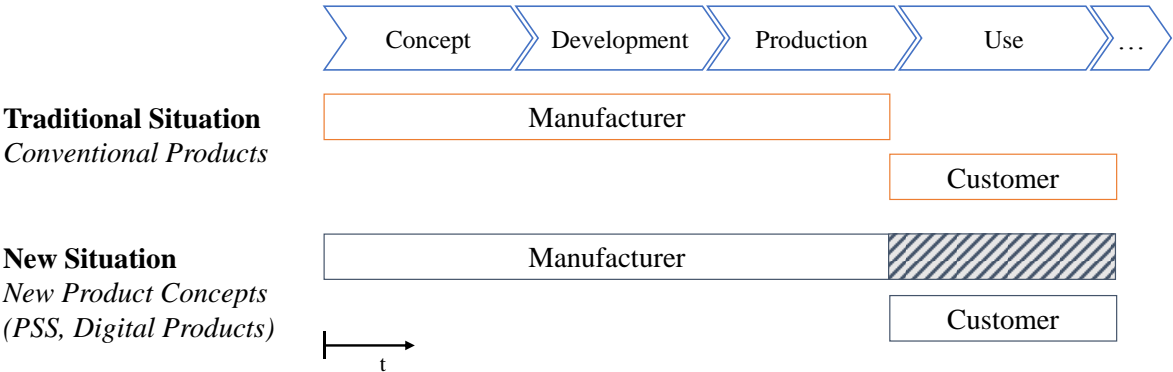
Moreover, in various markets a transition from offering purely technical products towards Product-Service Systems (PSS) takes place (Oliva & Kallenberg, 2003). A PSS consists of a tangible product and an intangible service (Tukker, 2004). Selling PSS can lead to different benefits (e.g., improved customer relationship, sustainability), but at the same time leads to new challenges in cost management because the service element needs to be integrated in the cost planning (Erkoyuncu, Roy, Shehab, & Wardle, 2009). Another emerging trend is

digitalization, which allows companies to increase their product offerings or include additional product features (Prahalad & Ramaswamy, 2003). Products offering digital user interaction will be subsequently also be referred to as digital products. Digital products often include service offerings (e.g., apps, cloud services, performance monitoring) and therefore share many characteristics with PSS (Thomas, Walter, Loos, Nuttgens, & Schlicker, 2007).

### 3 New Opportunities for Cost Management in Product Development

The literature review revealed the problems in current cost management. Companies are striving for a proactive cost management that starts early on and allows cost-related decisions to be made under uncertainty. However, challenges not only exist in cost management but also in product development itself because companies are offering digital products or PSS. The objective is to discover if companies can actually gain additional competitive advantages by offering PSS or digitalized products because of the fact that such products also inevitably introduce new challenges.

First of all, offering such products extends the responsibilities of the manufacturer (Wilberg, Hollauer, & Omer, 2015). Figure 2 illustrates the increased responsibility of manufactures, which means that a manufacturer needs to fulfill certain tasks or provide services during the use phase in order to satisfy the customers. The advantage of offering new product types is that such products provide a direct feedback loop back from the user to the manufacturer during the use phase (Terzi, Bouras, Dutta, Garetti, & Kiritsis, 2010).



**Figure 2. Change in the Manufacturer's responsibility for Different Products**

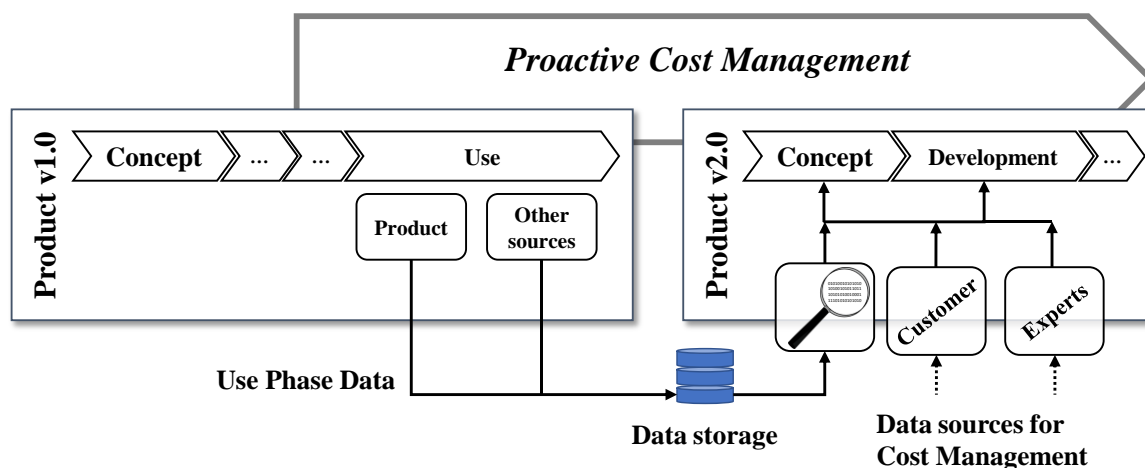
In the past companies often sold their products and subsequently had very few touchpoints with their products and customers (e.g., maintenance, repair). The new situation is a great opportunity to better understand customer needs and the use of the product because previously the information flow back to the manufacturer was often interrupted after products were sold (Terzi et al., 2010). The use phase data, which is generated by products (e.g., sensors or software) and services (e.g., apps), offers various new possibilities to support decision making or explore new opportunities (Jagadish et al., 2014). Staying in touch with the product during the use phase means also additional support for proactive cost management because the use phase information coming from the product helps to improve the market orientation and anticipation of cost management. However, the benefits of available use phase data cannot be taken for granted because companies need to plan the integration of data in their processes (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011). The objective of this paper is to analyze how proactive cost management can benefit from use phase data and how a suitable and adjusted data-driven cost management strategy can be derived.

## 4 Support for an Data-Driven Proactive Cost Management

### 4.1 Using new Data Sources for Proactive Cost Management

The previous discussion highlighted the opportunities, which PSS or digital products offer for companies. Therefore, the objective now is to further analyze how those opportunities can lead to improved proactive cost management. The aim is not to develop a new cost management approach but to strengthen the strategic implementation of the already existing ones. Proactive cost management needs to fulfill different requirements. One is that cost management should start early during product development. The IVE approach supports an earlier cost management. However, the crucial enabler for a successful application of TC, VE, and IVE is the amount and quality of the available information. The available knowledge and information is therefore a key to success. Understanding customer needs, actual product use and the market is important to make informed decisions on how to improve the functionality-cost ratio of products because a company can increase/decrease the costs, increase/decrease the functionality, or do both at the same time. A clear understanding of the product use is hence essential to make the right decisions and accordingly design the final product or portfolio.

Existing literature often mentions customer surveys, expert interviews, or questionnaires as the major data sources (Zengin & Ada, 2010). However, offering PSS or digital products allows companies to have a direct link to their products and customers during the use phase of the product. Use phase data is one aspect of the larger big data concept. Digitalization enables companies to directly collect and store data. The link between the product and the manufacturer establishes a feedback mechanism (Dellarocas, 2003). In general many “new” data sources (e.g., the internet, Facebook, Wikipedia, online platforms, sensors) exist but the focus of this paper is on data that is directly processed by the products itself or through a mobile application. The utilization of use phase data for cost management allows for reduction of uncertainty and the making of better informed data-driven decisions.



**Figure 3. Proactive Cost Management Integrating Use Phase Data**

However, the integration of those new data sources also requires a shift of the moment when proactive cost management should start. Figure 3 depicts when proactive cost management should start when use phase data is used as an additional input. The challenge with use phase data is that the data is generated after the product is sold. This type of data will therefore not be available during the concept phase. However, the data will be very helpful for the development of the next generation of the product (v2.0) because the data contains insights

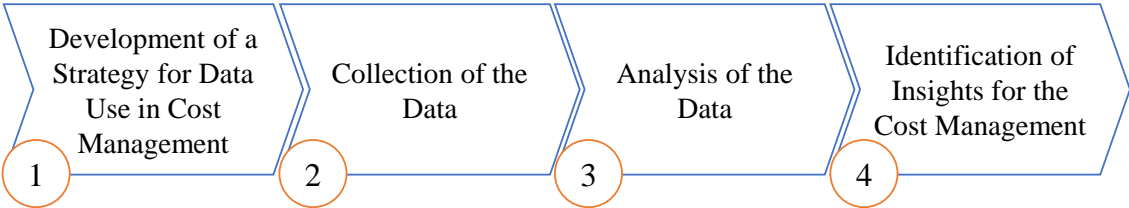
about the actual product use. The challenge is therefore to start with proactive cost management before the development of the next generation has perhaps even started. Strategic support is needed to assist companies in managing the transition towards proactive cost management that utilizes use phase data. Figure 3 also illustrates that use phase data is an additional data source, which is therefore a new puzzle piece that further reduces the uncertainty in cost management.

#### 4.2 Development of a Strategy for Proactive Cost Management.

The availability of use phase data is becoming a reality in many industries, but they need support in managing the data and using it for decision making (Krishnan, 2015). Therefore, the objective is to propose a process that helps companies in establishing proactive cost management that integrates use phase data as an additional information source.

The general process to handle use phase data consists of three steps: data collection, data analysis, and deduction of insights (LaValle et al., 2011). However, the three steps describe the technical tasks to handle data but an important initial step is missing. Before data is collected, unanswered questions (e.g., target costs, use of product functions, customer needs) must be identified to strategically use data to answer those questions.

Therefore, the paper proposes an extended process to manage the use phase data for cost management. Figure 4 depicts the process, which was developed based on the three basic steps. In the following the focus is on the first step of the process because a well-defined strategy for discerning how use phase data should support the cost management is crucial for the success of the initiative. Nowadays, the collection and storage of data is more or less technically state of the art. The challenge is to collect the right data that will help to gain business insights.



**Figure 4. Process for Data-Driven Proactive Cost Management**

Proactive cost management starts from an author’s perspective during the product development of predecessor product because engineers are required to look ahead and describe data that would be helpful for the development process of the next product. The **first step** of the proposed process is therefore to develop a strategy for data-driven proactive cost management. First of all, it is necessary to obtain an overview of the already existing use phase data sources (e.g., product, service, mobile application). Secondly, the objective is to identify the need for additional data support in the current cost management. Deriving the strategy for proactive cost management based on need follows the idea of pulling data into the organization instead of just collecting (push approach) all possible data. A good starting point to identify a need for data support in cost management would be to address those aspects that are especially uncertain. The IVE approach comprises of three product concretization domains and the target as well as the actual cost. Using a portfolio that classifies functions, requirements, and components depending on the degree of uncertainty and the percentage of the total costs could help to obtain a first overview about potential for data-driven proactive

cost management. The motivation behind the portfolio analysis is to reduce the uncertainty especially for expensive parts and to take advantage of use phase data for fast learning cycles.

After identifying aspects that could benefit from additional data support, the next step is to evaluate which of the existing data sources could help to reduce the uncertainties. In general it is also possible to run data analysis in order to identify new relationships in cost management but this approach requires more experience with evaluating data and is not within the scope of this work. In the case that no data is currently available, additional sensors or features should be integrated to generate the required data in case the value is greater than the effort. Afterwards, a document must be created, which includes the data that is collected and the cost management questions that should be answered. The development of a use phase data strategy for cost management should also include a discussion about the storage of the data and the implementation of the data link between the product and the storage.

The **second step** covers the actual data collection during the use phase of the product. The **third step** is very important to extract insights for the cost management. The analysis of the data should happen in cooperation with data analysts who help to apply suitable data analysis tools. In general, six approaches exist to analyze data: segmentation, variance analysis, classification, forecasting, association analysis, and sequence analysis (Müller & Lenz, 2013). The selection of the analysis methods depends on the data and also on the question which should be answered.

The **last step** of the proposed process is the most important one to generate value for the cost management. The challenge is to feed the gained insights back into cost management and product development. Therefore, it is crucial to define measures how the value of the product should be improved. The IVE approach especially offers support because the approach allows for the derivation of measures on a requirement, function, or component level. The data could for instance help to identify functions of the products that are very costly but are at the same time not used by the customer. Furthermore, the data could help to identify requirements that increase the product costs but are formulated far too conservatively and do not match the actual use cases of the product. These are only two examples of how use phase data can support the decision making process in cost management. The detailed analysis of data strongly depends on the context of application.

Overall, the process provides a framework for companies to reach improved data-driven decision making in cost management. Offering “modern” types of products therefore allows for a better understanding of a company’s own products during the use phase. Integrating data into cost management is an important step towards proactive cost management because it facilitates anticipatory behavior and avoidance of problems with product costs. Deriving a clear data strategy is an important enabler for faster learning cycles because systematically collected data addresses uncertainties in cost management.

## 5 Summary and Outlook

Global competition requires companies to develop products with a high value (ratio between functionality and cost) in order to stay competitive. Different approaches like IVE, TC or VE exist to support companies in developing products with a distinct value for such a competitive situation. Keeping product costs under control is crucial for sustainable financial success and challenging during product development. No matter which approach is chosen, they all highly depend on the input of information concerning product use, customer needs and market conditions. From a methodical standpoint support exists for cost management but from a



strategic standpoint room for improvement exists. Companies should aim for proactive cost management, which pursues anticipatory prevention of problems and continuous value optimization. Therefore, it is important to start with market oriented cost management early on during the product development process. Early integration however conflicts with the high information uncertainty at the beginning of product development, considering that informed decisions are important for successful cost management. Furthermore, cost management also faces challenges arising from new product offerings like PSS or advancing digitalization.

However, it appears that only new responsibilities for the companies arise from those product concepts, the changing product concepts also bear potential for cost management because they establish a direct feedback loop back to the manufacturer. Due to increased connectivity of the products, manufacturers collect use phase data from different sources like sensors or apps. Such use phase data helps to better understand the customer and the usage of the product, which provides valuable insights for proactive cost management. In the past cost management relied on tradition information sources like surveys or interviews. Being able to collect use phase data provides another new and valuable information source for manufactures. However, this additional information source also requires an adjustment of proactive cost management because the data is generated during the use phase of the predecessor product. In addition, companies need to identify and collect the right use phase data that helps to addresses uncertainties in cost management and to make better informed decisions concerning the product's value. Therefore, the paper introduced a process that supports companies in managing the transition towards more data-driven decisions in cost management.

The paper highlights the potential that use phase data offers for proactive cost management. However, it addresses the topics from a theoretical standpoint. The next steps will therefore be to conduct an industry case study. The goal is to further detail the proposed process and to work with real data in order to identify the potential for improving the value of a real product. The IVE approach will be used in this context because it allows for the optimization of the value on a requirements, functional, or components level.

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