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Managing the business benefits of product data management: the case of Festo

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Abstract

Purpose – The paper seeks to investigate the question as to how the business benefits of product data management (PDM) can be assessed and realized. In particular, it aims at understanding the means-end relationship between PDM and product data on the one hand and a company's business goals on the other hand.

Design/methodology/approach – The paper uses a case study research approach. The case of Festo is unique and allows for detailed examination of both the business benefits of PDM and of the inter-dependencies of various business benefit enablers. Due to the limited amount of scientific knowledge with regard to the management of PDM business benefits, the study is exploratory in nature. The conceptual framework used to guide the study combines business engineering concepts and the business dependency network technique.

Findings – The findings are threefold. First, the paper explicates and details the understanding of the nature of PDM business benefits. Second, it provides insight into the complexity and interdependency of various "means" – such as data ownership, product data standards, for example – and the "ends" of PDM, namely the contribution to a company's business goals. Third, the paper forms the baseline for a comprehensive method supporting the management of PDM business benefits.

Research limitations/implications – Single-case studies require further validation of findings. Thus, future research should aim at replicating the findings and at developing a comprehensive method for the management of PDM business benefits.

Practical implications – Companies may take up the results as a "blueprint" for their own PDM activities and may reflect their own business benefits against the case of Festo.

Originality/value – The paper is one of the first contributions focusing on the means-end relationship between PDM and product data on the one hand and a company's business goals on the other.

Keywords Product data management, Business benefits, Case studies, Data governance, Product lifecycle management, Business dependency network, Means-end relationship, Assessment method, Enterprise systems

Paper type Case study

1. Introduction

1.1 Motivation and problem statement

Product data management (PDM), in general, is a well-explored area of research. A significant amount of knowledge is available with regard to goals and tasks of PDM (Helms, 2002; Peltonen, 2000; Philpotts, 1996), the relationship between PDM and product lifecycle management (PLM) (Saaksvuori and Immonen, 2008; CIMdata, 2002), software systems for PDM (Kääriäinen *et al.*, 2000; Smith, 2004; Kropsu-Vehkapera *et al.*, 2009), and modeling and standardization of product data (Gielingh, 2008; Patil *et al.*, 2005; Shaw *et al.*, 1989).

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Apart from that, there have been scientific studies on business benefits companies seek to pursue when establishing PDM. Alemanni *et al.* (2008), for example, present key performance indicators for evaluating the business benefits. Earlier work comprises lists of "tangible" benefits to be realized in practice (Bryan and Sackett, 1997) and cases in which PDM has been implemented successfully (Harris, 1996).

While extant literature is of significant value for understanding the types of business benefits and related challenges and "success factors", not much knowledge is available when it comes to explicating how to actually assess and realize these benefits. A better understanding, though, of the "means-end" relationship (see Winter, 2008) between product data and PDM on the one hand and business benefits on the other is necessary both from a researchers' and a practitioners' perspective. Knowledge about this means-end relationship would allow not only to understand the benefits of PDM, but also to propose approaches and provide guidance for assessing and deliberately realizing business benefits by means of PDM. Also, practitioners would gain from this knowledge, as they need to know about the interdependencies between product data and business benefits in order to be able to "reproduce" successful PDM approaches.

1.2 Research question and approach

Already in the mid 1990s, Harris (1996) identified as an emerging research question: "What business benefits have organizations actually gained as a direct result of implementing PDM [. . .]?" The paper does not only respond to that question, but aims to take it one step further. It addresses the research question as to how companies may assess business benefits and how they can deliberately realize business benefits through PDM. In doing so, the paper investigates on the means-end relationships between a company's product data and the business goals it wants to achieve.

The paper uses a case study research approach. Case study research is an appropriate method when investigating contemporary phenomena, which cannot be isolated from their natural context (in contrast to lab experiments, for example) (Yin, 2002; Eisenhardt, 1989). The paper studies the case of Festo, a leading manufacturer of automation technology and provider of professional education services for technicians. Headquartered in Esslingen, Germany, Festo serves more than 300,000 customers worldwide. Two focus groups (Morgan and Krueger, 1993) with enterprise data managers from large organizations (see Appendices C and D) were used to address the data bias, which is natural in case study research and to triangulate the results.

The main part of the paper starts with an introduction of some basic terms and concepts, which is followed by a literature review regarding business benefits brought about by PDM in particular and by approaches for enterprise data management in general. The fourth section describes the research approach, followed by the presentation of the case study. Section six discusses the research results and specifies the contribution of the paper to the scientific body of knowledge. The paper concludes with a summary and an outlook to future research needs.

Fundamental terms and concepts

Product data

Product data are defined as "representation of information about a product in a formal manner suitable for communication, interpretation, or processing by human beings or computers" (ISO, 1994). Product data can be divided into three categories, namely:

(1) specification data;
(2) lifecycle data; and
(3) metadata describing both product data and lifecycle data (Saaksvuori and Immonen, 2008).

Specification data describe the characteristics and properties of a product (the product number, the name of the product, a short description of the product, the basic unit of measure, geometric information, etc). Lifecycle data describe the different stages a product goes through from its initial conceptual design until it is recycled or destroyed. Lifecycle data are used to control the product lifecycle (see below), as it indicates when a certain product moves from one stage to the next. Manufacture of a product cannot begin, for example, unless product drawings are approved. Metadata, in general, contain information about data. They describe the type of information, predefined values for certain items in a data set, and organizational responsibilities for data items.

Product data describe individual products, i.e. instantiations of an object class of products (Helms, 2002). Product data models are required for representation of products in information systems (McKay *et al.*, 1996). A product data model describes both the attributes of an object class of products and the relationships between the classes.

Terminologically, product data are closely related to product information. In general, data turns into information when used in a certain context. Therefore, some authors refer to data as the "raw material" of "information products" (Krcmar, 1996; Wang *et al.*, 1998). Companies use multiple information products that are made up of product data (product brochures in sales and marketing, information sheets on the physical dimensions and weight of a product in logistics, product geometries used in manufacturing, for example).

Moreover, product data are often referred to as master data. Master data describe the key business objects in a company, such as customers, suppliers, assets, and products (Loshin, 2008; Dreibelbis *et al.*, 2008). Master data can be divided into global and local master data. Global master data must be unambiguously defined and used across the entire company, whereas local master data typically are used in one particular country or location only.

High-quality master data are critical for business success (Otto, 2011b). Haug and Arlbjørn (2011) have identified obstacles companies must overcome to improve and ensure master data quality. One obstacle is related to the assignment of clear responsibilities for the maintenance of master data.

The need for intra- and extra-company exchange of product data has fostered the development of product data standards. A prominent example is the ISO 10303 specification, which is also known as STEP (STandard for the Exchange of Product model data).

2.2 Product data management

A large body of knowledge exists concerning product data management (PDM) (Bryan and Sackett, 1997; Hameri and Nihtilä, 1998; Harris, 1996; Helms, 2002; Peltonen, 2000; Kääriäinen *et al.*, 2000). However, all these studies take a system oriented perspective. Harris (1996), for example, proposes that PDM should be part of the overall information systems infrastructure.

The paper argues that this viewpoint is too limited and does not reflect the importance product data and PDM has for companies. PDM should rather be seen as an organizational function. Therefore, the definition of data management in general, as proposed by the Data Management Association (DAMA, 2009, p. 4), is transferred to the domain of product data. The paper suggests to see PDM as the organizational function for planning for, controlling of, and delivering product data. This function includes all design, execution, and supervision tasks regarding product data plans, projects, processes, practices, and systems.

A PDM system (PDMS) is defined as a software system, which offers functionality to support PDM. As mentioned above, numerous studies have been carried out investigating the functionality a PDMS should provide (Peltonen *et al.*, 1996; Helms, 2002; Hameri and Nihtilä, 1998; Philpotts, 1996; Peltonen, 2000). Philpotts (1996), for example, has identified six functional categories:

(1) data vault and document management;

(2) workflow and process management;

(3) product structure management;

(4) classification;

(5) program management; and

(6) utility functions, such as data transport, data translation, image services, communication, and notification.

Numerous standard software systems supporting PDM are available on the market today. A good overview is provided by consulting company Pumacy Technologies (2011). However, no integrated system support for PDM exists today which supports all activities across the entire product lifecycle (Gielingh, 2008; Kropsu-Vehkapera *et al.*, 2009). Often, companies use at least two application systems for supporting PDM: an "engineering oriented" system for managing product structures and integrating drawings etc from Computer Aided Design (CAD) systems, and a "business oriented" system managing product data required for logistics, manufacturing, and distribution processes.

From an architectural point of view, PDMS must integrate with numerous surrounding systems, such as computer-aided design (CAD), document management, groupware, and enterprise resource planning (ERP) systems (Peltonen, 2000, p. 74 *et sequation*; Hameri and Nihtilä, 1998). As a result, many PDMS are designed as central systems which hold a "golden record" of product data, distribute the data to connected systems, and reduce redundancies in data handling.

Recent research on PDMS has been driven by the need for semantic integration of product data in collaborative environments, taking into account the fact that effective PDM requires an unambiguous understanding of product data among all parties involved (first- and second-tier suppliers, engineers, sales agents, supply chain managers, for example) (Patil *et al.*, 2005; Gielingh, 2008).

Product lifecycle management (PLM)

PDM is closely related to PLM, which is defined as "a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life, integrating people, processes, business systems, and information" (CIMdata, 2002). Companies typically organize PLM as a business process (Schuh *et al.*, 2008). While PDM takes a data oriented perspective on a company's products, PLM focuses on the activities required to manage the products. In doing so, a PLM process comprises PDM activities. Consequently, a PLM system includes functionality of a PDMS.

Some authors have pointed out that the use of the terms PDM and PLM has changed over time. They argue that PLM has simply replaced PDM without adding additional meaning (Saaksvuori and Immonen, 2008). While the paper concedes that there has been, of course, a terminological evolution over time with regard to PDM and PLM, it also argues that both concepts exist in their own right (in the distinction described above).

3. Business benefits of PDM, enterprise systems, and ERP: a literature review

The literature review that was conducted does not only cover examinations addressing the benefits of PDM. It rather takes a broader perspective, including also related concepts with a strong focus on enterprise wide data integration. Most notably, among these concepts are Enterprise Systems and ERP. A search for relevant literature identified a large number of papers (see Appendix 1). Further analysis of the literature, however, revealed a more differentiated picture, as illustrated in Table I.

The analysis used the typology of theories in information systems (IS) as proposed by Gregor (2006) as a lens to examine the theoretical contribution of previous research to the existing body of knowledge with regard to business benefits brought about by PDM in particular and by Enterprise Systems and ERP in general. Analytical theories mainly analyze and describe contemporary phenomena, but do not explain them. Explanatory theories take up on this, addressing mainly "how", "why", and "when" questions. Predictive theories provide testable propositions on the cause-effect relationships between different concepts – often referred to as dependent and independent variables – of the phenomenon under investigation. Finally, design and action theories address means-end relations and aim at designing reality (Gregor, 2006).

The literature review shows that the scientific body of knowledge, as it is today, appears to be somewhat unbalanced. Regarding analytical theories, a lot of contributions can be found which analyze and describe the business benefits of PDM in particular and of integrated data management approaches in general. The analysis of business benefits through PDM experienced a peak some ten years ago. A more recent study deals with the identification of business benefits from a process perspective on PLM (Schuh *et al.*, 2008). Many of these studies have in common that – besides analyzing and describing the business benefits – they aim at assigning these benefits to different "layers" of the enterprise. For example, a distinction is often made between organizational and technical benefits (Sackett and Bryan, 1998). Examples of organizational benefits are reduced product lifecycle cost, reduced time-to-market, improved product quality, or improved process flexibility. Direct technical benefits comprise aspects such as the sharing of data across product domains, data consistency and integrity, or concurrent process support. These general benefit categories have been confirmed by other studies (CIMdata, 2002). Sackett and Bryan (1998), however, point out that exact forms of these benefits will vary from one company to the other. A lot of research has also been undertaken to analyze the business benefits of Enterprise

Table I. Literature review overview

Type of theory	Key questions	PDM domain	ES/ERP domain	Summary
Analysis	What are the benefits?	CIMdata (2002), Harris (1996), Kropsu-Vehkapera *et al.*, (2009), Philpotts (1996), Sackett and Bryan (1998), Schuh *et al.* (2008)	Schubert and Williams (2011), Spathis and Ananiadis (2005)	Identification and description of benefits; allocation of benefits to different enterprise "layers"
Explanation	When and under what conditions can the benefits be realized?	Hameri and Nihtilä (1998), Smith (2004)	Irani and Love (2001), Shang and Seddon (2002), Strong and Volkoff (2010), Velcu (2007)	Identification/specification of success factors, challenges, "benefit patterns", and organizational fit
Prediction	What are the cause-effect relations of realizing the benefits?	Lin *et al.* (2006)	Chien and Tsaur (2007), Ettlie *et al.* (2005), Federici (2009), Hitt *et al.* (2002), Wieder *et al.* (2006), Yang and Su (2009)	"If-then" statements for relating implementation and benefits, and contingency factors and benefits; application of the IS Success Model by DeLone and McLean (1992)
Design and action	What needs to be done to assess and realize the benefits? What are the means-end relations?	Alemanni *et al.* (2008)	Estevez (2009)	Individual contributions only, focus on individual aspects

Notes: PDM – product data management; ES – enterprise systems; ERP – enterprise resource planning

Systems and ERP. Very recently, Schubert and Williams (2011), for example, came up with a framework for identifying and understanding enterprise systems benefits.

Explanatory theories focus mainly on success factors, challenges, and requirements, which must be met in order for PDM and/or Enterprise Systems and ERP to be implemented successfully. Many case studies fall into this category (e.g. Hameri and Nihtilä, 1998), as well as a number of surveys among companies which implemented an enterprise system (e.g. Shang and Seddon, 2002).

Predictive theories can be found mainly in the broader fields, dealing with the identification of contingency factors or with general IS success models that have been applied. As far as the field of PDM is concerned, this type of theory can hardly be found. One of the few contributions has been a paper by Lin *et al.* (2006) investigating the semiconductor industry in Taiwan.

Finally, very few design and action theories can be found addressing the question as to how PDM business benefits – or benefits of Enterprise Systems and ERP – can actually be assessed and realized. There are some papers that discuss the nature of implementation approaches (e.g. Schuh *et al.*, 2008). While this is undoubtedly of high value, it does not respond to the research question of the paper at hand. A study which does address "means-end" relations in the field of Enterprise Systems is the "benefits realization road-map framework" (Estevez, 2009). This framework consists of four stages, namely "Prepare", "Realize", "Achieve", and "Auditing", and refers to benefits on both a strategic and an operational layer. In the field of PDM one of the few examples of a design and action theory is a case study conducted at Alcatel Alenia Space, which shows that the use of key performance indicators can be an adequate approach to evaluate the benefits of PLM (Alemanni *et al.*, 2008).

Summarizing, the literature review suggests that the body of knowledge concerning the business benefits of PDM and related concepts is dominated by theories for analyzing, explaining, and predicting. These contributions are of highest significance for both researchers and practitioners, as they help increase the understanding of the nature and type of the benefits as well as of their causes and effects. However, these theories leave further questions open. Both the scientific and the practitioners' community are interested in understanding in more detail how these benefits can be assessed and realized, and what constraints exist (see Rangan *et al.*, 2005, p. 236). To put it in slightly provocative terms: The current body of knowledge treats the issue of business benefits of PDM as a "black box", focusing on prerequisites and challenges when it comes to PDM. A more detailed, "white box" approach for analyzing the complex means-end relations between PDM and business benefits on different enterprise "layers" is missing.

4. Research approach

4.1 Case study research design

The paper uses case study research to investigate business benefits brought about by PDM. Case study research is adequate if the phenomenon under investigation cannot or should not be isolated from its context, and if it is still relatively unexplored (Benbasat *et al.*, 1987; Yin, 2002). The research design follows the five guiding points proposed by Yin (2002, pp. 21-28).

The research question (1st guiding point) is derived from the research problem, namely limited knowledge about concrete business benefits of PDM. Therefore, the central research question is: How can companies assess and realize business benefits by means of PDM?

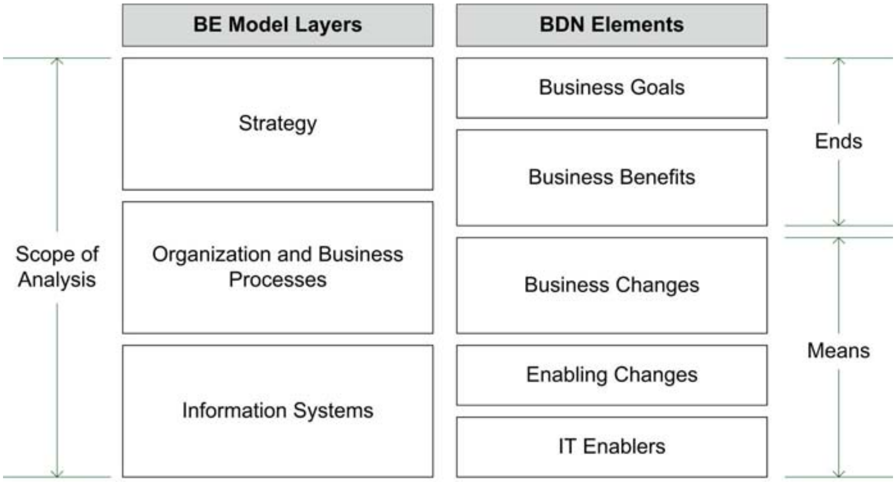
Due to the limited amount of scientific knowledge with regard to this question, the study is of exploratory nature. Yin (2002) concedes that in exploratory case studies it is unlikely to base one's research on clear propositions (2nd guiding point). However, he stipulates that case study research should have some purpose (Yin, 2002, p. 22), and that it should follow a set of criteria guiding the investigation. The paper uses a conceptual framework (see Figure 1) as a guiding scheme for the investigation. The Conceptual Framework combines two approaches from literature, which aim at analyzing and designing the interplay of IS and business goals. The first approach is Business Engineering, which is a model oriented and method driven design approach to be used by companies. Business Engineering assumes that transformation efforts have effects on three layers of a company, namely "Strategy", "Organization and Business Processes", and "Information Systems" (Österle, 1996; Davenport and Short, 1990). The Conceptual Framework suggests that in order to understand and determine the business benefits of PDM one has to investigate all three model layers. Literature confirms that such an integrated perspective is basically appropriate (Harris, 1996). The second approach used by the Conceptual Framework is the Business Dependency Network (BDN) (Ward and Daniel, 2006), which is a technique designed to examine means-end relations between "IT enablers" and "Business Goals".

The unit of analysis (3rd guiding point) sets the boundaries for the case with regard to generalizability of its results. The paper uses a single-case design, studying how Festo approaches the issue of assessing and realizing the business benefits of PDM.

The Conceptual Framework also functions as the logic which links the data to the propositions (4th guiding point), and it provides the lens for analyzing and interpreting the findings (5th guiding point).

4.2 Case selection and data collection

Festo represents a unique case (Yin, 2002, pp. 40-41), as the company looks back on a relatively long history of PDM and has undertaken – in contrast to many other



Notes: BE – Business Engineering; BDN – Business Dependency Network; IT – Information Technology

Figure 1. Conceptual framework

companies – substantial efforts to quantify the benefits of PDM. Furthermore, Festo was invited to be presented as "best practice" in PDM at a practitioners' seminar on master data management, which took place on October 6, 2009, in Bad Homburg, Germany (Huber, 2009). The case of Festo can therefore be considered as highly unique and suitable for laying the foundations for further research.

Data was collected from different sources (see Appendix 2). The main data source, however, were interviews with subject matter experts from Festo. Transcripts of the interviews were created on the basis of the field notes from the researchers involved. The final case study report was sent to Festo for approval. A similar approach of single-case study research was chosen by Lemmergaard (2008) and by Schroeder and Pauleen (2007), for example.

Given the nature of single-case study research the paper does not aim at developing a fully elaborated theory. It rather wants to explore the fundamental concepts of the relations between PDM and a company's business goals as well as of the assessment of those relations. Following Walsham (1995) the paper wants to find "tendencies rather than predictions" (pp. 79-80).

In order to take into account the limitations of single case studies with regard to replicability and generalizability (Kennedy, 1979, Eisenhardt, 1989) two focus groups were conducted for triangulation purposes (for details see Appendices 3 and 4). Focus groups, in general, aim at finding consensus on a contemporary topic within a certain community (Morgan and Krueger, 1993). In the research setting presented in this paper, the focus groups were used to approve the research question, to confirm the unit of analysis, and to discuss preliminary results.

Product data management at Festo

5.1 Company overview

Festo is a world leading manufacturer of automation technology and also market leader in professional education for technicians. Headquartered in Esslingen, Germany, the company aims at maximizing profitability and competitiveness of its customers in the factory and process automation industry. With 14,600 employees Festo generated revenue of 1.8 billion euros in 2010. The Festo Group comprises 59 independent national companies and 250 locations worldwide, and serves more than 300,000 customers. The product portfolio comprises both catalog parts and custom specific solutions. In total, Festo offers more than 30,000 catalog parts in several hundred thousand variants. Festo invests 8.5 percent of its revenue into research and development.

5.2 Business strategy

Festo's business strategy is characterized by a set of business goals:

- ensuring financial independence as a family owned company;
- focusing defined areas of growth while at the same time protecting existing business segments;
- developing standardized business processes and continuously improving them in terms of cost, time, and quality;
- ensuring and fostering the personal development of employees in the sense of a learning organization.

Festo has operationalized these strategic goals through a number of performance measures, which are shown in Table II.

While the "Financial" perspective uses standard performance measures, the measure "Service level" of the "Customer" perspective, for example, materializes in service coverage across 176 countries, a 24-hours pick-up and delivery service, and electronic availability of all product information to the customer. A metric related to delivery time is the percentage of orders delivered in 24 hours after order entry. As for "Internal" performance measures, flexibility is defined as the "ability of a system to change status within an existing configuration", whereas agility refers to the "ability of a system to rapidly reconfigure" (Bernardes and Hanna, 2008). In other words, flexibility relates to foreseeable or anticipated changes, whereas agility refers to the speed of reaction to an unpredicted change in the environment (Helo, 2004). Festo uses these measures to balance the advantages of standardization (e.g. of business processes) with the need to respond quickly to changing customer needs.

Examples of metrics used to measure innovation at Festo are the number of newly introduced products per year or the percentage of sales revenue invested in staff training (Festo, 2008).

5.3 Organizational structure and business processes

Festo's organizational structure reflects the company goal of meeting customer demands on a global scale. As a result, market supply is organized in three stages:

(1) Global Production Centers (GPCs) form the backbone of the market supply. GPCs ensure fulfillment of primary demands for components and finished goods, and they supply the Regional Service Centers (RSCs). GPCs aim at low production costs and pooling of core competencies.

(2) Regional Service Centers (RSCs) aim at supplying regional markets with the entire product range at minimal delivery times. Apart from that, RSCs are responsible for producing regional product variants.

(3) National Service Centers (NSCs) serve markets, which cannot be served at reasonable delivery times by RSCs. Moreover, NSCs function as "extended work bench" for custom specific product configurations.

BSC perspective	Performance measures
Financial	Cost of goods sold Growth Profitability SG&A cost
Customer	Service level Delivery times
Internal	Agility and flexibility Degree of standardization Process costs, cycle time, and quality
Learning	Innovation

Notes: BSC – balanced scorecard; SG&A – sales, general and administrative expenses

Table II. Performance measures at Festo

Festo's organizational structure is also reflected in its main value creation processes, namely the production and sales of catalog parts as well as the development and sales of custom specific solutions. Figure 2 shows the Festo Innovation Network, which combines the organizational structure and the two main value creation processes.

Festo's process organization consists of ten business processes, of which one is the "Product Lifecycle Process" (other business processes are, for example "Project Engineering" or "Order Processing and Delivery"). The Product Lifecycle Process comprises four sub-processes, namely "Product Strategy", "Product Development", "Product Optimization", and "Product Phase Out".

Festo makes a distinction between products and parts. While products in the narrower sense are goods, which are sold to customers, parts are semi-finished goods, which are not directly sold to customers.

The Product Lifecycle Process is managed by a central department, which reports to the "Technology and Infrastructure" unit. The department employs 27 people. Its six main tasks are:

(1) standardization and classification;

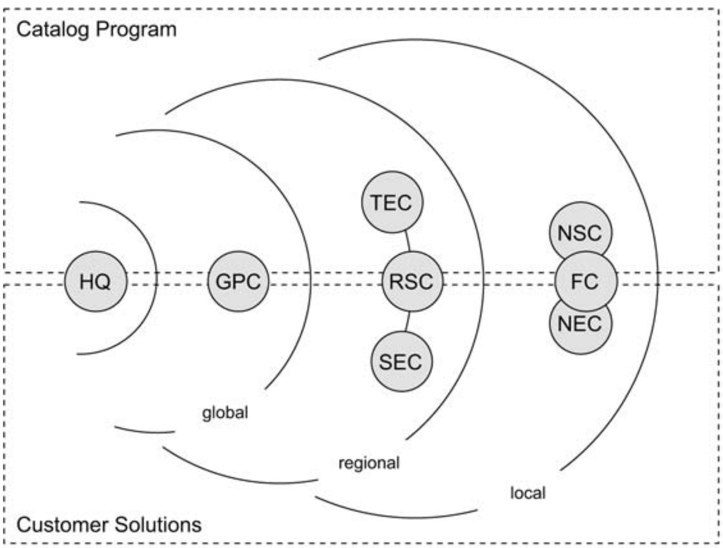
(2) product characteristics management;

(3) basic data management;

(4) quality assurance of drawings;

(5) change management; and

(6) support for data of new product introductions.



Notes: HQ – Head quarter; GPC – Global Production Center; NSC – National Service Center; RSC – Regional Service Center; TEC – Technical Engineering Center; SEC – Solution Engineering Center; NEC – National Engineering Center

Figure 2.
Festo innovation network

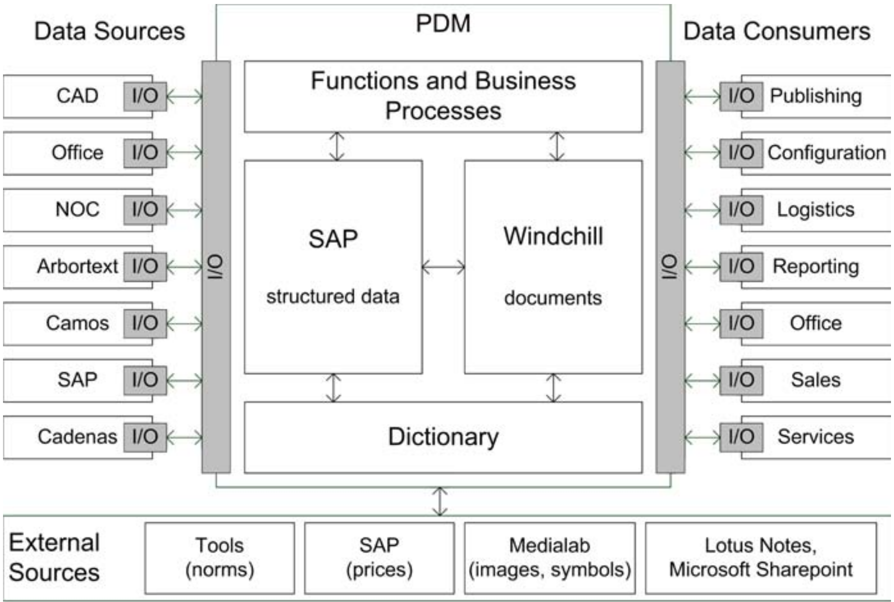
The product data, which are managed by the Product Lifecycle Process comprise data which are required for design, development, production, and support of the physical goods. In addition, product data needed for logistics are managed by the Product Lifecycle Process. An example of such data are procurement cycle times needed for manufacturing requirements planning (MRP).

5.4 PDM system

Festo uses standard software application systems on a company-wide level. The PDM system is a combination of two major application systems (see Figure 3).

The first system is a SAP ERP system, which is used to manage product data. As a second system, Festo uses Windchill by PTC for product management and documentation. The PDM connects various data source systems with numerous data target systems. Examples of source systems are office applications and CAD systems. Examples of target systems are publishing systems for print media, reporting systems, as well as three regional SAP ERP systems, which are used for supporting business processes in sales, production, and logistics.

Of particular importance to Festo is the distribution of high-quality "global" product data to connected regional SAP ERP systems in Europe, Asia and Australia, and America. Global product data are product master data (e.g. product IDs, texts), bills of material (BoMs), classification and specification data (used for product identification and description), and constraint information. The central PDM system distributes product data for newly introduced products and when existing products are modified. The target systems then hold a local copy (see Schwinn and Schelp, 2005) of the global product data.



Notes: I/O – Input and output interface; CAD – Computer-aided Design. The SAP system for price maintenance (see external sources) is a separate SAP instance

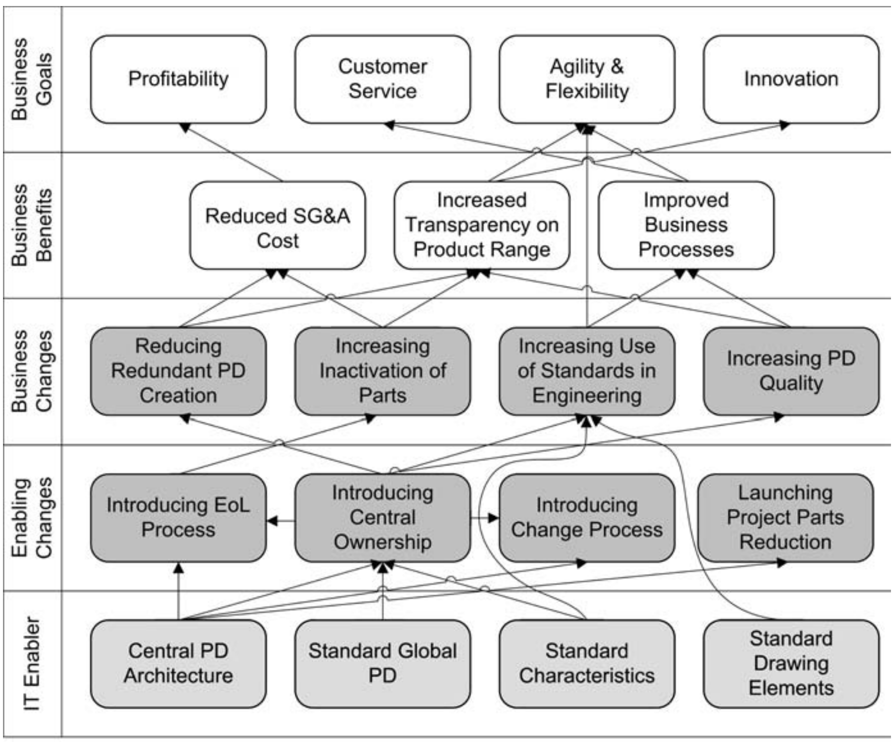
Figure 3.
Festo's PDM system

5.5 Benefit analysis

Festo is able to realize business benefits through PDM. These benefits include "direct technical" and "organizational" benefits (Bryan and Sackett, 1997). The company, however, decided to analyze the benefits in more detail in order to be able to quantify the business benefits both on the Strategy layer and on the Organization and Business Processes layer, and to better understand the relationships between the benefits on these two layers and the benefits on the Information Systems layer.

Figure 4 shows the analysis of the business benefits using the Benefits Dependency Network (BDN) technique (Ward and Daniel, 2006, p. 133 et sequation). The analysis shows that the IT enablers related to PDM have no direct effect on the company's business goals. Instead, they enable changes, which in turn lead to changes in the way business is conducted. These business changes result in business benefits, which contribute to the achievement of overall business objectives.

Assessment of business benefits is explained using an example of a certain "path" through the BDN. Three IT enablers, namely the central product data architecture (based on the PDMS shown in Figure 3), the definition of standardized global product data attributes, and the introduction of catalogs of standardized product characteristics, led to two enabling changes, namely the introduction of an end-of-lifecycle process for products and the introduction of central ownership



Key: EoL – End of Lifecycle; Information Systems; Organization and Business Processes; Strategy Layer in Business Engineering; PD – Product Data

Figure 4.
Benefits dependency network analysis

regarding product categories and related product data. Both enabling changes have led to business changes, in particular changes in the Product Lifecycle Process.

Among these business changes are:

- *Reduction of redundant part data creation*: Festo has managed to reduce the number of requests for new parts. In the past, engineering had requested new parts not being aware of the existence of a similar part with the same characteristics, leading to creation of redundant parts. With PDM Festo is now able to increase the re-use ratio of parts.
- *Increased deactivation of parts*: Festo has managed to increase deactivation of parts which are not used in saleable products any longer or which can be replaced by other products. Without central PDM, Festo had had no transparency about parts, which were potential candidates for deactivation.
- *Increased use of standards in engineering*: Clear responsibilities for product segments (in the production centers) and for basic characteristics and drawing elements (in the PDM department) are prerequisites for the use of standards in engineering processes.

Especially being able to avoid redundant part data and better identify parts to be deactivated has led to a relative reduction in the number of part data records at Festo. As an example, Figure 5 shows the evolution of the number of semi-finished steel products at Festo until the year 2008 (with the number of parts in 2000 considered as 100 percent). The graph shows that after the business changes of reducing the number of redundant parts and increasing deactivation of useless parts the number of parts went down by 3 percent by 2008 compared to the initial situation in 2000, and by some 12 percent compared to the situation in 2004, when the business changes became effective.

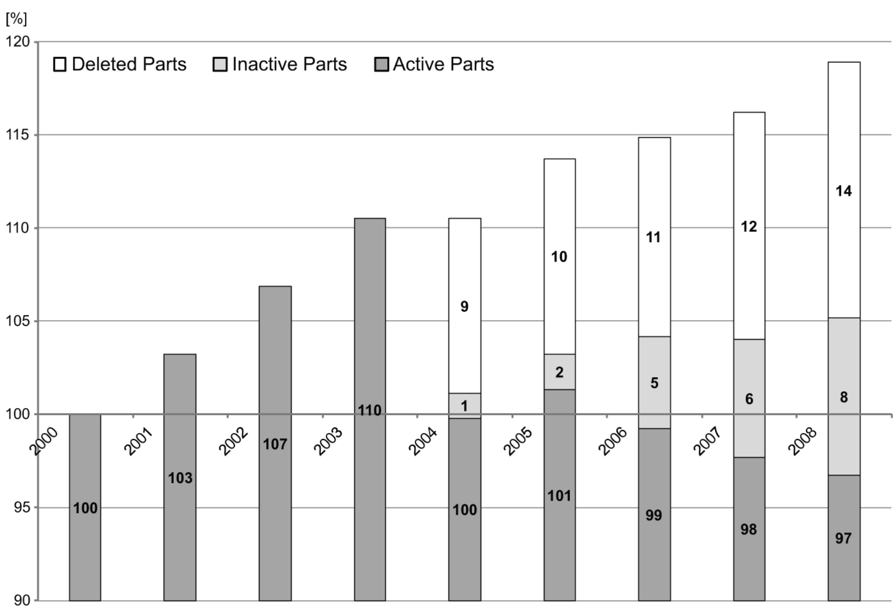


Figure 5.
Number of semi-finished steel parts at Festo over time

It is important to note that the reduction of active semi-finished steel parts had no counter-effect on innovation. In fact, the number of saleable products grew by 5,805 on the yearly average between 2004 and 2008.

Based on the analysis of the evolution of the number of parts over time, Festo initiated an effort to quantify the monetary effect brought about by the business changes (see Table III). A cost analysis project was started to determine the costs that occur in various departments involved in the Product Lifecycle Process (see first column in Table III). Furthermore, the percentage of PDM related activities compared to all activities in these departments was determined, as well as the distribution of the PDM activities to either new products or changes to existing products. This information was available from the time recording system used at Festo.

Table III shows that for every 1,000 euros spent on Sales, General and Administrative (SG&A) expenses (total value in the first column) 471 euros are spent for the creation of new products, and 442 euros are spent for changing existing products.

To determine the total monetary benefits realized, Festo calculated cost rates for both creation and maintenance (i.e. ongoing changes) of a product:

- The cost rate for processing a new product request is 5,000 euros. The value is calculated by dividing the overall SG&A costs for new products (absolute, non-normalized value) by the average number of new products per year.
- The cost rate for managing an existing product is 500 euros. The value is calculated by dividing the overall SG&A costs for changes (absolute, non-normalized value) by the average overall number of active products and distribution of that value over the average lifecycle (eight years).

For 2008 the benefits in terms of avoided SG&A costs resulted in a total value of about 12 million euros.

The other two business benefits that could be identified by the BDN analysis, namely increased transparency regarding the product range and improved business processes, have strengthened the position of PDM in the organization, but were not analyzed further or even quantified.

Depart.	Annual overall costs (€)	Percentage of PDM activities (%)	New products (%)	Annual overall costs, new products (€)	Changes (%)	Annual overall costs, changes (€)
R&D	458	90	65	268	35	144
PM	113	80	85	77	15	14
BM	23	20	100	5	0	0
Patents	14	100	100	14	0	0
Ind. Eng.	22	100	70	15	30	7
Value Mngmt.	8	100	60	5	40	3
QA	109	100	60	65	40	44
Catalog Mngmt.	27	100	40	11	60	16
Log. and Inv. Mngmt.	226	100	5	11	95	214
Totals	1,000			471		442

Notes: R&D – Research and development; PM – Product management; BM – Business management; Ind. Eng. – Industrial engineering; Mngmt. – Management; Log. – Logistics; Inv. – Inventory

Table III.
SG&A cost analysis

5.6 Success factors

Festo identified four PDM success factors:

(1) *Company-wide mutual agreement*: all hierarchy levels and business units in the organization understand and support the ambition to achieve an optimum for the company as a whole, even if the "global" optimum may not always be the optimal solution for local units – for example, the introduction of SAP as a standard application system and the use of standard global product data.

(2) *Business process design*: all business changes on the Organization and Business Processes layer are designed to be applicable on a worldwide basis.

(3) Automation through software support: Software supports the global use of product data and newly designed business processes.

(4) *Central ownership*: central PDM does not mean a central PDMS only, but requires centralized, global responsibility for product data.

6. Case discussion

6.1 The nature of the PDM benefits

Quantifiable benefits in the case of Festo relate mainly to "cost avoidance", because PDM supports identifying parts of products the marketing of which has become economically disadvantageous. Through deactivation of these parts Festo is able to avoid the cost of their management and maintenance. The cost categories in the case of Festo (see Table III) largely corresponds with literature (Steiner, 1996). Technically, the cost savings refer to opportunity costs, i.e. to costs which would have occurred had the company chosen a different alternative of action – namely not establishing PDM and continuing creating redundant parts and marketing products with decreasing or even negative profit contribution. This does not diminish the positive impact of PDM. However, it also means that the money saved cannot be cut from the budget of a certain organizational unit (what is often demanded in times of "do more with less", as stated by participants from the focus groups):

> In the end, if the savings cannot be cut from somebody's budget, controlling will hardly accept your cost-benefit analysis (Manager Data Quality, Deutsche Telekom AG, in Focus Group 2 on December 2, 2009).

The analysis of the PDM business benefits at Festo adds to the scientific body of knowledge because it goes beyond existing literature on the business benefits of PDM, which mainly identifies benefit categories – such as "reduction of product cycle time" (Sackett and Bryan, 1998) and "cost savings in manufacturing" (Philpotts, 1996) – without specifying them any further. In contrast to that, the paper provides a detailed documentation about PDM benefits using the example of opportunity costs.

6.2 Benefit enablers

The case of Festo illustrates the complex network of IT enablers and organizational enablers, and the interdependencies between them. Understanding this complexity and these interdependencies, though, is necessary to close the scientific gap, i.e. to be able to come up with more design and action theories with regard to managing the business benefits of PDM (see Section 3). Four examples of "means" which must be understood to assess and realize certain "ends" – i.e. the benefits discussed in Section 6.1 – relate to:

(1) product lifecycle;
(2) product data quality;
(3) data governance; and
(4) integration of product data and product information.

The case of Festo shows the importance of PDM covering the entire lifecycle of products (1). Although this might seem an obvious point, many companies fall short of actively managing especially the end of a product's lifecycle (Jun *et al.*, 2007). Deactivation of parts, however, had the most significant contribution to the cost savings and therefore on the profitability of Festo. With this research result the paper addresses a research need, which has been frequently articulated in literature (see, e.g. Jun *et al.*, 2007; Hameri and Nihtilä, 1998).

Apart from that, improved product data quality (2) has been a central business change at Festo. It required not only IT enablers (central product data architecture, standardized global data and product characteristics), but also enabling changes, in particular the introduction of central and clear ownership as a result of data governance (3) for product data:

> We also created standardized operating procedures, for example, but I think that was not the decisive factor in the end. The main reason for the adoption [of standardized characteristics] is data quality. When today users log on to the system, they can rely on the data and they will find the data they search for. [. . .] User acceptance is higher now. That has to do with communication, but also with data quality. I think standardized operating procedures were not the key (Head of Product Lifecycle Management, Festo, in a case study interview on November 26, 2009).

Both the researchers' and the practitioners' community refer to the definition and assignment of decision rights concerning data management in companies as Data Governance (Khatri and Brown, 2010; Otto, 2011a). In the understanding of Business Engineering, Data Governance as an organizational concept forms the "hinge" between the Information Systems layer and the Strategy layer. Data Governance is necessary for establishing data quality management as a continuous function in the organization – which was also confirmed by the case study participants:

> Otherwise you will end up with the same figures again. Then you will achieve no reduction [of parts] at all and have to start all over again (Head of Product Lifecycle Management, Festo, in a case study interview on November 26, 2009).

The close relation between product data quality and product data ownership confirms recent scientific findings concerning the assignment of data maintenance responsibilities (Haug and Arlbjørn, 2011). And, furthermore, the paper contributes to the emerging debate on Data Governance by introducing a successful approach for assigning data management responsibilities in the case of product data.

The success of PDM at Festo required close integration of product data and product information (4). While the demand for an integrated view on all product related information (be it master data, drawings, or multimedia information) is not new (Tsao, 1993), companies still encounter difficulties when trying to integrate product information and product data. One reason might be that the functional scope of PDM and the functional scope of product information management typically are covered by different application systems (Lin *et al.*, 2006). Also, Festo is using two different systems (Windchill and SAP), which are highly integrated though. Furthermore, the understanding of tight integration of product data and product information as an IT enabler for achieving business goals contributes to what Peltonen (2000) refers to as an "important question, which probably has no single 'correct' solution" (p. 179).

6.3 The role of an assessment methodology

The case of Festo shows that the business benefits of PDM are significant and that measures must be taken for assessing these benefits. However, the case also shows that a methodological approach is required in order to handle the complexity of the interdependencies of means and ends on different Business Engineering layers, and to allow for repetition of the approach. Thus, making the means-end relations transparent is a prerequisite not only for a one-time benefit assessment, but – even more important – for continuous assessment of the contribution of PDM to a company's business objectives. Transparency regarding the "mechanisms" of costs and benefits of PDM forms a basis for being able to evaluate changes on all Business Engineering layers. The Conceptual Framework as a combination of Business Engineering on the one hand and BDN on the other lays the foundation for a PDM business benefit assessment method. Such an endeavor would help close the design and action theory gap identified in Section 4.

While the general approach was basically confirmed by the participants of Focus Group 1 (see Appendix 3), concerns about the effort needed to apply it were raised also:

> Before being able to use the approach, we must know our baseline [. . .], the actual cost [for data management] we're coming from. [. . .] It is necessary to concentrate on improvements, not on full costs (Manager Business Data Excellence, Nestle S.A., in Focus Group 1 on April 23, 2009).

Finally, identification of means-end relations between PDM and business benefits directly responds to open research questions in literature. Harris (1996), for example, asks whether "any of the success of leading companies has been caused by the introduction of PDM" and what "business benefits have organizations actually gained as a direct result of implementing PDM" (p. 216). And Rangan *et al.* (2005) call for research "to better understand and facilitate [. . .] benefit metrics" (p. 236).

Conclusions and outlook

The paper investigates the question as to how business benefits of PDM can be assessed and realized. It draws on the existing body of knowledge regarding benefits brought about by PDM in particular and benefits achieved through related enterprise data approaches in general. Furthermore, the paper addresses the current gap in research concerning design and action theories which focus on the means-end relations between PDM and a company's business benefits.

The results of the paper are threefold. First, the paper allows a more detailed understanding of the nature of the benefits of PDM. Second, it yields insight into the critical enablers, which must be addressed in order to realize benefits. And third, the paper lays the foundation for a design and action theory for assessing and realizing benefits of PDM.

The paper makes several contributions to the scientific body of knowledge. On the one hand, it offers insight as to how companies may assess the business benefits of PDM. The findings of the Festo case provide both details on the actual benefits achieved and the approaches and techniques used to assess them. On the other hand, the paper identifies means, which must be in place in order to be able to realize the benefits. Transparency over these means is important to advance the body of explanatory and predictive theories and to close the gap with regard to design and action theories, not only in the field of PDM, but also in the related areas of Enterprise Systems and ERP (see Section 3). In doing so, the findings from the Festo case form the foundation for a comprehensive method for managing business benefits.

Practitioners may benefit from the results because they can use the case study as a "blueprint" for their own PDM efforts. Moreover, they can use the results in order to promote the idea of PDM within their own organization. Furthermore, the methodological approach can be taken up by practitioners to establish an ongoing "benefits realization monitoring".

Presenting the results of single-case study research the paper has imitations with regard to replicability and generalizability (Lee, 1989). However, the combined use of Business Engineering and BDN allows for replication of the research for similar cases in the future. The question for generalizability has to be related to the purpose of a single-case study. As the nature of the single-case study is exploratory, it does not aim at producing an elaborated theory, but rather wants to yield first insight as to how companies may assess and realize the business benefits of PDM. Walsham (1995) refers to this type of generalization as "drawing of specific implications" and calls them "tendencies rather than predictions" (pp. 79-80). Thus, future research should develop further the findings toward a more elaborated theoretical framework of PDM business benefits and necessary prerequisites.

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Appendix 1. Literature search

A literature search was performed to analyze the scientific body of knowledge with regard to the benefits of enterprise-wide data management in general and PDM in particular. Five online databases were searched through using the following search strings:

- ("Enterprise System" OR "ERP") AND ("Benefit" OR "Value"); and
- "Product Data" AND ("Benefit" OR "Value").

Table AI shows the results of the literature search. The results were extended through a heuristic search on Google Scholar.

	AIS Electronic Library	ACM Digital Library	CiteSeerX	Emerald	JSTOR
Date of most recent search	11/15/2011	11/15/2011	11/15/2011	11/15/2011	11/15/2011
Search settings	Advanced search	Advanced search, journals, transactions, proceedings	Advanced search	Advanced search, journals	Advanced search
Searched fields	Abstract	Abstract	Abstract	Abstract	Abstract
Results in total	0	85	163	294	0
Most relevant results	n/a	Chien and Tsaur (2007), Eynard *et al.* (2004), Gielingh (2008), Karimi *et al.* (2007)	Gattiker and Goodhue (2000), Hallikainen *et al.* (2002), Shang and Seddon (2004)	Dezdar and Ainin (2011), Estevez (2009), Ettlie *et al.* (2005), Federici (2009), Kropsu-Vehkapera *et al.* (2009), Spathis and Ananiadis (2005), Velcu (2007), Wieder *et al.* (2006), Yang and Su (2009)	n/a

Table AI.
Literature search

Appendix 2. Data sources

Table AII shows the data sources which were used in the case study.

Data source	Description
Interviews	November 26, 2009: 10.00 am to 3.00 pm, Esslingen, Germany. Festo participants: Head of Product Lifecycle Management; Head of Master Data Administration; Head of Characteristics Management April 13, 2010: 1.00 pm to 2.00 pm, Düsseldorf, Germany. Festo participants: Head of Product Lifecycle Management April 28, 2010, 1.00 pm to 2.00 pm, telephone call. Festo participant: Head of Product Lifecycle Management
Presentations	Presentation of Festo at a practitioners' seminar, namely the "Stammdaten-Management Forum 2009" (German: Master Data Management Forum) in Bad Homburg, Germany (Huber, 2009).
Internal Documents	Documentation of the development of the number of parts over time; Performance metrics and values of the PDM unit; Job descriptions of department SI-L
Corporate communication	Press release "Festo on course for global growth" from April 19, 2010 Press release "Festo on track for success in global growth markets" from June 9, 2011

Table AII.
Data sources

Appendix 3. Focus Group 1

Table AIII shows the participants of Focus Group 1, which took place on April 23, 2009, in Mörfelden, Germany. The focus group interview was conducted within the research program (name blinded for review) at the University (name blinded for review).

The overall topic of the focus group discussion was the cost of data quality. In the discussion the researcher acted as a moderator. After an introduction to alternative cost models – namely Total Cost of Ownership, a standard model for bureaucracy costs, life-cycle costing and activity-based costing – the group was asked to discuss the following aspects:

- Cost categories relevant for data quality management.
- Examples of baseline values for cost categories.

The results of the focus group were documented on a flip-chart paper.

Company	Industry	Headquarter	Participants
Bayer Crop Science AG	Chemicals	Germany	Head of Enterprise Master Data Management Manager Master Data Management
Beiersdorf AG	Consumer goods	Germany	Head of Data Process Management Master Data Architect
Corning Cable Systems	Manufacturing	Germany	Head of Data Management Organization Manager Master Data Management
DB Netz AG	Transportation	Germany	Two Managers Infrastructure Data Management
Deutsche Telekom AG	Telecommunications	Germany	Head of Data Governance Manager Data Quality
Hilti AG	Manufacturing	Liechtenstein	Analyst Costumer Data Quality
Nestle S.A.	Consumer goods	Switzerland	Manager Business Data Excellence
Novartis Pharma AG	Pharmaceuticals	Switzerland	Manager Master Data Management (IT)
Oerlikon Textile	Manufacturing	Germany	Project Lead Customer Master Data
Syngenta Crop Protection AG	Chemicals	Switzerland	Head of Master Data Management Shared Services

Table AIII.
Participants in Focus Group 1

Appendix 4. Focus Group 2

Table AIV shows the participants of Focus Group 2, which took place on December 2, 2009, in Nuremberg, Germany. This focus group too was conducted within the research program (name blinded for review) at the University (name blinded for review).

After an introduction of the topic of the focus group the researcher presented a list of questions as an input to the discussion (see below). In the discussion the researcher acted as a moderator. The results of the focus group were documented on a flip-chart paper. The focus group questions were:

- What are indirect costs, which should be taken into consideration?
- Would data be available?
- Is Lifecycle Costing (LCC) a reasonable measure?
- What is the benchmarking object? Sales article or material?
- Is it valid to attribute savings to MDM?
- What are metrics for cross-company benchmarking (e.g. revenue/number of material numbers)?

Company	Industry	Headquarter	Participants
Bayer Crop Science AG	Chemicals	Germany	Head of Enterprise Master Data Management Manager Master Data Management
Beiersdorf AG	Consumer goods	Germany	Head of Data Process Management Master Data Architect
DB Netz AG	Transportation	Germany	Two Managers Infrastructure Data Management
Deutsche Telekom AG	Telecommunications	Germany	Head of Data Governance Manager Data Quality
IBM Deutschland GmbH	Software and services	Germany	Manager Sales
Nestle S.A.	Consumer goods	Switzerland	Manager Business Data Excellence
Novartis Pharma AG	Pharmaceuticals	Switzerland	Head of Master Data Management in Supply Chain Management Manager Master Data Management
SAP AG	Software	Germany	Manager Research
SGL Group	Automotive	Germany	Manager Master Data Management
Siemens Enterprise Communications GmbH & Co. KG	Telecommunications	Germany	Head of Enterprise Master Data Management
Syngenta Crop Protection AG	Chemicals	Switzerland	Lead Master Data Architect

Table AIV. Participants in Focus Group 2

About the author

Boris Otto is a Research Fellow at the Center for Digital Strategies at the Tuck School of Business at Dartmouth College and Assistant Professor at the University of St Gallen. His main areas of research are enterprise data management, data governance, enterprise systems and business engineering. Prior to his current positions, Boris Otto worked for PricewaterhouseCoopers, Fraunhofer IAO, and SAP. He holds a Dr-Ing. degree from the University of Stuttgart and a Dipl.-Ing. Oec. degree from the Technical University of Hamburg-Harburg. Boris Otto can be contacted at: Boris.Otto@tuck.dartmouth.edu