Towards a Taxonomy for Coordinating Quality of Master Data in Product Information Sharing

(Completed Research Paper)

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Abstract: Achieving and maintaining an adequate level of master data quality is one of the most challenging issues in product information sharing. Product information sharing denotes synchronizing product master data across companies. It is a major prerequisite for efficient supply chains and for digitizing inter-organizational relationships. However, product information sharing has gained only little attention from scholars. In three iterations, we develop and evaluate a taxonomy for product information sharing. The theoretical basis for iteration 1 is coordination theory. The empirical basis for iteration 2 was established by a review of the literature on product information sharing. In iteration 3, three expert interviews helped us to evaluate and to advance the taxonomy. The taxonomy aims at providing a structure for further research and for supporting practitioners in identifying starting points for improving product information sharing.

Keywords: Taxonomy, Master Data, Data Quality, Information Quality, Inter-organizational Data Synchronization, Product Information Sharing, Coordination Theory

1 Introduction

Achieving and maintaining an adequate level of master data quality is one of the most challenging issues in product information sharing (de Corbière 2007; Legner and Schemm 2008; Hüner et al. 2011; Schäffer and Stelzer 2017). Product information can be defined as a set of data, e.g., product name, identification number, description, weight, size, etc., that represents a product (de Corbière 2007; Madlberger 2011a; Dalmolen et al. 2015). Product information sharing denotes the inter-organizational transfer of master data relating to products, a concept labeled "product information supply chain" by Legner and Schemm (2008). The term master data refers to critical business objects. It describes products, suppliers, customers, employees, and similar objects that rarely undergo changes (Loshin 2008).

Intra-organizational issues of ensuring and improving quality of master data have gained extensive attention in the literature (Wang and Strong 1996; Madlberger 2011a). However, master data quality in inter-organizational business processes – particularly in product information sharing – has had much less attention (de Corbière 2007; Legner and Schemm 2008; Madlberger 2011a; Dalmolen et al. 2015).

In a review of 972 peer-reviewed journal and conference articles on data and information quality published over the last 20 years Shankaranarayanan and Blake (2017) found that "DQM for Electronic Data Exchange" – a research topic dealing with inter-organizational data exchanges and focusing on e-commerce and EDI – has increasingly gained attention in recent years. The authors also emphasize that organizations face significant barriers to effectively implement master data management (MDM) and that this research field needs more attention from researchers.

Product information sharing is a major prerequisite for efficient supply chains and for digitizing inter-organizational relationships (de Corbière 2007; Legner and Schemm 2008; Hüner et al. 2011; Koçoğlu et al. 2011). Numerous studies have found that many companies are concerned about the quality of product information shared with partners (de Corbière 2007; Legner and Schemm 2008; Schäffer and Stelzer

2017). Poor quality of product data exchanged across companies may lead to substantial cost increases or loss of sales (Nakatani et al. 2006; Legner and Schemm 2008; Hüner et al. 2011). Moreover, product information sharing is a problematic, error-prone, labor-intensive, and costly process in many companies (Nakatani et al. 2006; de Corbière 2007; Legner and Schemm 2008; Hüner et al. 2011; Falge et al. 2012; Le Dû and de Corbière 2011; Madlberger 2011a; Schäffer and Stelzer 2017).

However, master data quality relating to product information sharing is a research topic that has gained only little attention from scholars. Thus, several authors (de Corbière 2007; Legner and Schemm 2008; Le Dû and de Corbière 2011; Falge et al. 2012; Dalmolen et al. 2015) encourage further research into inter-organizational exchange of product information.

In view of the practical relevance of this domain and the lack of research into the field, a taxonomy might be a helpful basis both for research and organizational practice. A taxonomy is an orderly classification of objects according to their presumed relationships (Bailey 1994). The purpose of a taxonomy is to define classes of objects – and subclasses if applicable – and relations among them (Berners-Lee et al. 2001). Taxonomies enable researchers to study relationships among concepts and hypothesize possible relationships (Nickerson et al. 2013). Taxonomies also help practitioners to tackle problems by finding causes of problems and starting points for improvements (Nickerson et al. 2013; Khalilijafarabad et al. 2016).

In the information/data quality field the importance of taxonomies is well recognized. A number of taxonomies have been proposed (e.g., LeRouge and Gjestland 2002; Jayewardene et al. 2012; Bosu and MacDonell 2013; Zogla et al. 2015; Khalilijafarabad et al. 2016). These taxonomies can provide research foundations in the form of a common domain language in which problems and their solutions can be defined and explored. It seems, that most taxonomies in the information/data quality field focus on data quality problems and research issues. However, the process of achieving or improving data quality in inter-organizational settings does not seem to have been in the focus of taxonomies. To the best of our knowledge, we do not know any study that has proposed a taxonomy of enhancing master data quality in product information sharing.

The objective of our research is to develop and to evaluate a taxonomy for coordinating quality of master data in product information sharing.

This paper is organized as follows. First, we give a short overview of our methodology. Next, we describe the steps to develop and to evaluate the taxonomy. Iteration 1 is based on an analysis of coordination theory. The empirical basis for iteration 2 was established by a review of the literature on product information sharing. In iteration 3, three expert interviews helped us to evaluate and to advance the taxonomy. We conclude with a summary of our results and suggestions for future research.

2 METHODOLOGY

Several authors have published methods for taxonomy development (Choi et al. 2009; Nickerson et al. 2013; Šmite et al. 2014). We select the method proposed by Nickerson et al. (2013) as it covers all perspectives relevant for our research project: data quality, inter-organizational MDM, and product information sharing. Figure 1 gives an overview of our methodology. Nickerson et al. (2013) suggest using a procedure model consisting of the following steps: 1) Determine a meta-characteristic that sets the framework for the taxonomy and serves as a foundation for selecting key concepts and characteristics. 2) Determine ending conditions which help to determine when to terminate the development process. Nickerson et al. (2013), then, suggest combining two approaches (a conceptual and an empirical approach) and to use both approaches in an iterative manner to best reach a useful taxonomy. 3) In the conceptual approach, the researcher develops a taxonomy starting with a conceptual or theoretical foundation and then derives the typological structure through deduction. 4) The empirical approach starts with data and derives the classification from this data. The goal is to find similarities among the data and to classify similar objects into the same category. Nickerson et al. (2013) emphasize that researchers may need several iterations of applying these approaches before a useful taxonomy has been reached. They recommend using ending conditions that help to decide when to end the taxonomy development process. These ending conditions will be described in section 3.2. At the end of the process the resulting taxonomy needs to be evaluated. Nickerson et al. (2013) suggest checking whether the ending conditions have been met and asking potential users to evaluate the usefulness of the taxonomy. If the evaluation reveals that the taxonomy is not sufficiently useful, understandable, or complete, the process needs to be restarted until a taxonomy has been developed that meets all relevant criteria.

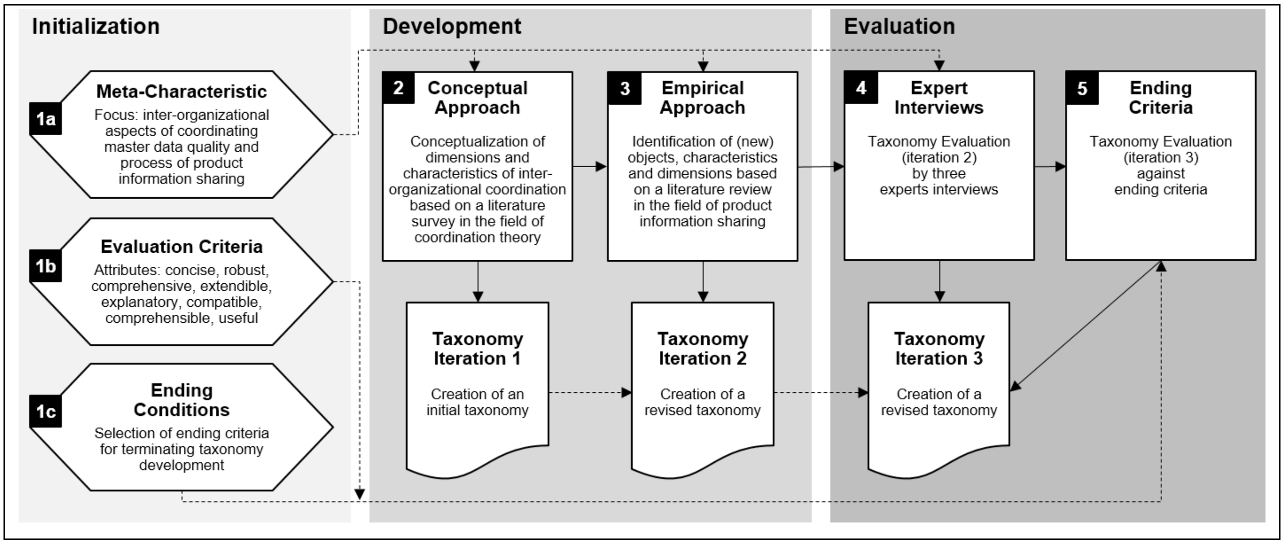

Figure 1: Taxonomy development method adapted from Nickerson et al. (2013)

3 TAXONOMY DEVELOPMENT

Nickerson et al. (2013) specify a taxonomy as a set of n dimensions each consisting of k mutually exclusive and collectively exhaustive characteristics. The authors propose that a useful taxonomy has the following attributes:

- It is concise. It contains a limited number of dimensions and characteristics in each dimension.
- It is robust. It contains enough dimensions and characteristics to differentiate the objects of interest.
- It is comprehensive. It provides for classification of all current objects in the specific domain.
- It is extendible. It allows for inclusion of additional dimensions and new characteristics within a dimension when new types of objects appear.
- It is explanatory. It contains dimensions and characteristics that do not describe every possible detail of objects but, rather, provides useful explanations of the nature of the objects under study.

Our taxonomy is intended to be useful for both researchers and practitioners. It shall serve as a guide for future research and support practitioners in their struggle for improving quality of master data in product information sharing. We therefore add three more attributes:

- It is compatible with relevant theories. In the present case this implies that the taxonomy covers key concepts of coordination theory (Malone and Crowston 1990, 1994). In section 3.3 we explain why we selected coordination theory as a theoretical basis for our study.
- It is comprehensible. Practitioners with sufficient knowledge in product information sharing can easily understand the taxonomy.
- It is useful. The taxonomy may support scholars in exploring product information sharing and practitioners in coordinating data quality in inter-organizational exchange of product master data.

In the following sections, we describe five steps for developing and evaluating a taxonomy for product information sharing. We present three iterations which lead to interim results (iteration 1 and 2) and to our final proposal (iteration 3) for a taxonomy. Figure 1 gives an overview of our development process.

3.1 Determine Meta-Characteristic

Nickerson et al. (2013) suggest the following guidelines for determining a meta-characteristic. It should be based on the purpose and the expected use of the taxonomy. This requires considering the eventual users of the taxonomy. The target audience of our taxonomy comprises academics and practitioners interested in product information sharing. Therefore, the taxonomy should be suitable to identify key concepts and characteristics to study relationships among these concepts. It should also support practitioners in identifying root causes of problems and starting points for problem resolution in product information sharing.

Nickerson et al. (2013) suggest specifying the domain of interest that is to be structured by the taxonomy as closely as possible. First, as already mentioned above, we focus on inter-organizational aspects of coordinating master data quality. Thus, we do not analyze methods, mechanisms, and tools used to achieving, maintaining, and improving quality of master data primarily within organizations. Second, we focus on the process of product information sharing, not on the results of this process, i.e., quality of product master data. Quality characteristics of master data exchanged across companies have already been explored by other authors (Vermeer 2000; Cai and Shankaranarayanan 2004; Le Dû and de Corbière 2011; Falge et al. 2012).

Nickerson et al. (2013) found that identifying a suitable meta-characteristic is an iterative process. Often, it can only be specified during the taxonomy development process. This is in line with our experiences. Although we describe the meta-characteristic at the outset of the development process, it only became clear during the process. For example, we identified coordination theory as a theoretical foundation for exploring quality of master data in product information sharing only after analyzing several studies mentioned in the empirical approach (cf. section 3.4).

3.2 Determine Ending Conditions

Nickerson et al. (2013) recommend using objective and subjective ending conditions for terminating taxonomy development. They suggest a list of objectives ending conditions and advise researchers to select matching conditions for their research project. We selected the following conditions:

- The taxonomy must consist of dimensions each with mutually exclusive and collectively exhaustive characteristics.
- All objects or a representative sample of objects have been examined.
- No object was merged with a similar object or split into multiple objects in the last iteration.
- At least one object is classified under every characteristic of every dimension.
- Every dimension is unique and not repeated (i.e., there is no dimension duplication).
- Every characteristic is unique within its dimension (i.e., there is no characteristic duplication within a dimension).
- Each cell is unique and is not repeated (i.e., there is no cell duplication).

Nickerson et al. (2013) also emphasize that this process may lead to useful, but not necessarily to optimal solutions. They suggest that researchers may choose to start taxonomy development with either the empirical or the conceptual approach. We decided to begin with the conceptual approach. For reasons of brevity, we present an abbreviated description of our process of taxonomy development. The actual process was much more complicated. It covered a period of 22 months. The three iterations presented here actually consisted of various iterations within the three approaches (conceptual approach, empirical approach and evaluation). In this paper, we focus on key elements of the process.

3.3 Conceptual Approach

The conceptual approach derives a taxonomy from theory or conceptualization. It identifies dimensions and characteristics by a logical process derived from a sound conceptual or theoretical foundation.

We build on coordination theory as a basis for taxonomy development. Malone and Crowston (1994) define coordination as “the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals”. Coordination theory is the “body of principles about how activities can be coordinated, that is, about how actors can work together harmoniously” (Malone and Crowston 1990). We selected coordination theory as a theoretical basis, in particular for the following reasons: First, although companies that share product information often have incongruent competitive goals (e.g., suppliers attempt to sell goods at high prices, whereas customers wish to procure goods at low prices) trading partners also pursue congruent operational goals (e.g., implementing and maintaining efficient supply chain activities, establishing a smooth and cost-efficient flow of data, cutting rework cost). Thus, coordination theory focuses on an essential question of product information sharing, namely, how cooperating organizations can manage interdependencies resulting from the need to operate on high quality product master data. Second, coordination theory has been successfully applied by prior research into product information sharing (Legner and Schemm 2008; de Corbière 2009; Schäffer and Stelzer 2017).

We structure the conceptual approach into two substeps: conceptualization of characteristics and dimensions of objects (section 3.3.1) and creation of an initial taxonomy (section 3.3.2).

3.3.1 Conceptualization of Characteristics and Dimensions

In the conceptual approach, the researcher begins by conceptualizing the dimensions of the taxonomy without examining actual objects (Nickerson et al. 2013). Our basis for identifying characteristics and dimensions for inter-organizational coordination is the result of a literature survey covering papers on coordination theory. We focused on a) papers exploring general and inter-organizational coordination (Thompson 1967; Van de Ven et al. 1976; Bensaou and Venkatraman 1993, 1996; Crowston 1994; Malone and Crowston 1994; Sahin and Robinson 2002; Romano 2003; Samaddar et al. 2006) and b) papers presenting frameworks, classifications, typologies, or taxonomies of inter-organizational coordination (Malone and Crowston 1990; Alexander 1993; Whang 1995; Nassimbeni 1998; Xu and Beamon 2006; Arshinder et al. 2011; Blostein 2014).

Our review lead to a wide range of concepts related to inter-organizational coordination. Thus, we had to define criteria for selecting concepts for inclusion in the taxonomy. The rationale and criteria for selecting concepts were as follows: We first selected key concepts of inter-organizational coordination. We considered a concept to be a key concept if it was referred to by the majority of papers mentioned in the preceding paragraph and if it was included in at least one of the frameworks of inter-organizational coordination mentioned in section b) of the last paragraph. We then evaluated whether the concept allows for a meaningful distinction of objects and characteristics in inter-organizational coordination, or more specific: in product information sharing. We identified and selected the following concepts:

Types or configurations of inter-organizational relationships are organized into three classes by most authors (Whang 1995; Romano 2003; Samaddar et al. 2006; Blostein 2014). A dyadic network involves the interaction between two organizations (1:1). A multiple dyadic network involves the interaction of one organization with several other organizations (1:n or m:1). A many-to-many network is one where several organizations interact with several other organizations (m:n) (Samaddar et al. 2006).

Coordination structure entails managing interdependencies between activities (Samaddar et al. 2006). In a highly centralized structure the locus of authority and decision making resides at a single point. In a highly decentralized structure the authority and decision making is dispersed. Hybrid coordination structures combine various forms of centralization and decentralization.

Actors denote individuals or groups of individuals who take part in an activity (Malone and Crowston 1990; Alexander 1993) – in our case in an activity for coordinating quality of master data in product information sharing. A coordinator is an individual appointed to coordinate the activities on an inter-organizational system. A coordinating unit expands the coordinator's role to an independent organizational unit (Alexander 1993).

Activities include both, performing tasks and achieving goals. Activities are actions performed to achieve a particular state or objective (Crowston 1994). At this stage of taxonomy development, we did not identify characteristics for activities as these are highly domain specific and cannot reasonably be subdivided into general classes.

Goals are ends toward which efforts are directed (Crowston 1994). Literature focusing on coordination distinguishes corporate, team, and individual goals (Crowston 1994; Whang 1995).

The **perspective** denotes the mental view of coordination within or across organizations. Whang (1995) proposes three different perspectives: The single-person perspective assumes that coordination is managed by a hypothetical single decision maker who has access to all information and makes all decisions quickly and rationally without pursuing individual objectives. The team perspective emphasizes the existence of several units who take on different roles in coordination. Each unit has limited information and action sets, so they need to communicate and coordinate their activities to achieve the global objective. The team perspective assumes that coordination takes place in full cooperation among the organization members. All units have a single objective and all members share the same objective while working separately. The nexus-of-contract perspective follows the tradition of agency theory (Jensen and Meckling 1976) in which an organization is a nexus of contracts among self-interested agents, each maximizing his or her personal objective.

It is obvious that the last two dimensions, goals and perspective, are not independent of each other. Considering team or individual goals implies that an organization cannot be viewed or explored from the single-person perspective. Put differently, if a researcher assumes that coordination activities are driven by team or individual goals, she or he should adopt the team or nexus-of-contract perspective.

Interdependencies denote the relationships of two or more objects being influenced or determined by the other object(s). According to Malone and Crowston (1990) interdependencies are “goal-relevant relationships between the activities”. Interdependencies imply that two or more actors must take each other into account if they are to accomplish their goals (Crowston 1994). Xu and Beamon (2006) add that interdependencies may arise between activities or organizations. Referring to Thompson (1967), Bensaou and Venkatraman (1993) break interdependencies into three sub-categories: pooled, sequential, and reciprocal interdependencies. Pooled interdependencies denote a state where activities share or produce common resources but are otherwise independent. Sequential interdependencies exist if some activities depend on the completion of others before beginning. Reciprocal interdependencies describe a state where the output of each activity becomes the input for another activity.

Coordination mechanisms are methods used to manage interdependencies between activities (Xu and Beamon 2006). Coordination tools are specific elements of organizational action, interaction or behavior that enable coordination (Alexander 1993). A rich variety of classifications to structure coordination mechanisms can be found in the literature: (Thompson 1967) identifies three different mechanisms: standardization (predetermined rules govern the performance of each activity), plan (decomposing the process of achieving goals into a sequence of elementary activities), and mutual adjustment (each actor makes on-going adjustments to manage interdependencies). Van de Ven et al. (1976) distinguish impersonal (plans and rules), personal (vertical supervision), and group (formal and informal meetings) coordination mechanisms. Nassimbeni (1998) refers to Mintzberg (1979) when structuring coordination mechanisms into direct supervision (a central entity coordinates the actions of other units), standardization (pre-definition and codification of the tasks of each unit; standardization can involve inputs, outputs, processes, and skills), and mutual adjustment (works mainly through informal communication processes). We decided to adopt the classification by Nassimbeni (1998). Thus, we structure coordination mechanisms into direct supervision, standardization and mutual adjustment. As plans can be understood as a special case of standardization, namely standardization of inputs, outputs, or processes, we did not identify plans as an independent characteristic.

3.3.2 Creation of Initial Taxonomy (Iteration 1)

Table 1 summarizes findings of our analysis of papers focusing on inter-organizational coordination. It shows dimensions, characteristics and descriptions of concepts that will be further refined and modified in the next iteration.

Dimension	Characteristic	Description
Type of relationship	dyadic network	involves the interaction between two organizations (1:1)
	multiple dyadic network	involves the interaction of one organization with several others (1:n or m:1)
	many-to-many network	involves several organizations interacting with several other organizations (m:n)
Coordination structure	centralization	locus of authority and decision making resides at a single point
	decentralization	locus of authority and decision making is dispersed
	hybrid	various forms of combinations of centralization and decentralization
Actors	coordinator	an individual appointed to coordinate the activities on an inter-organizational system
	coordinating unit	expands the coordinator's role to an independent organizational unit
Activities		actions performed to achieve a particular state or objective
Goals	corporate	ends toward which corporate efforts are directed
	team	ends toward which team efforts are directed
	individual	ends toward which individual efforts are directed
Perspective	single-person	assumes that coordination is managed by a hypothetical single decision maker
	team	emphasizes the existence of several units who take on different roles in coordination
	nexus-of-contract	assumes self-interested coordination agents, each maximizing his or her personal objective
Interdependencies	pooled	activities share or produce common resources but are otherwise independent
	sequential	some activities depend on the completion of others before beginning
	reciprocal	the output of each activity becomes the input for another activity
Coordination mechanisms and tools	direct supervision	a central entity co-ordinates activities and synchronizes the other actors
	standardization	consists of pre-definition and codification of activities, skills, inputs, or outputs
	mutual adjustment	each actor makes on-going adjustments to manage interdependencies

Table 1: Taxonomy of inter-organizational coordination after iteration 1

3.4 Empirical Approach

The empirical approach involves observing empirical cases, which are then analyzed to determine dimensions and characteristics. Nickerson et al. (2013) suggest that this can be achieved by a review of the literature. We structure the empirical approach into three substeps: literature review, identification of (new) objects, characteristics and dimensions, and creation of a revised taxonomy (iteration 2).

3.4.1 Literature Review

We followed the guidelines provided by Webster and Watson (2002) to identify relevant publications. As a first step, we examined information systems, computer science, and business journals and conference proceedings using the AIS Electronic Library, ScienceDirect and Google Scholar. We also included the proceedings of the International Conference on Information Quality in our review. We conducted electronic searches in titles and abstracts on the following search term: [((“data” OR "information") AND “quality”) OR (“product” AND “information” AND “sharing”) OR (“data" AND ("exchange” OR "synchroniz*” OR "sharing")) AND (“inter-organizational” OR "interorganizational" OR “business-to-business” OR “supply chain”)]. These searches identified a total of 305 publications. After analyzing each article’s abstract, keywords, or the full article when necessary, we excluded 274 articles that were duplicates or did not appear to be concerned with or relevant to our research focus. As a third step, we performed a forward and backward search in relevant articles to identify further sources that had not been identified by the previous step. A total of 37 publications were read in full and coded. We excluded all publications that only stated the keywords mentioned in the search term without elaborating on these concepts. Out of the 37 coded articles, 24 include passages of interest (Cai and Shankaranarayanan 2004;

de Corbière 2007, 2009; Myles 2006; Nakatani et al. 2006; Becker et al. 2008; Legner and Schemm 2008; Madlberger 2008, 2011a, 2011b; de Corbière and Rowe 2010a, 2010b, 2013; Datta and Christopher 2011; Hüner et al. 2011; Boukef Charki et al. 2011; Ibrahim and Nicolaou 2011; Koçoğlu et al. 2011; Le Dû and de Corbière 2011; Falge et al. 2012; Tengberg 2013; Ginet 2014; Dalmolen et al. 2015; Schäffer and Stelzer 2017). We used our initial taxonomy (iteration 1) as a coding scheme for the literature. We analyzed the 24 papers for mentions and descriptions of the dimensions and characteristics included in iteration 1. We also watched out for new objects, dimensions, and characteristics relating to product information sharing. In section 3.4.2, we present findings of our analysis. We have documented the findings of our literature review in more detail in an appendix to this paper. This appendix is available at www.tu-ilmenau.de/informationsmanagement/taxonomy-product-information-sharing.

3.4.2 Identification of (new) Objects, Characteristics, and Dimensions

All **types or configurations of inter-organizational relationships** described in iteration 1 were also found in the literature on product information sharing. Examples for a dyadic network are two companies that exchange price or catalog data via EDI connections (de Corbière and Rowe 2010a). A supplier of consumer goods providing a customer portal for wholesale traders establishes a multiple dyadic network (de Corbière and Rowe 2010b). A data pool receiving product data from many manufacturers and providing data to several trading companies is an example for a many-to-many-network (Legner and Schemm 2008; Le Dû and de Corbière 2011).

When analyzing the literature for statements on coordination structures, it became obvious that product information sharing entails two types of coordination structures. The first denotes the coordination structure for a supply chain comprising various companies. We use the term **supply chain coordination structure** to describe this type. In some supply chains one (or a few) powerful organizations dominate the coordination structure (Dalmolen et al. 2015). In other supply chains coordination structures are decentralized (Cai and Shankaranarayanan 2004). The second type, **corporate coordination structure**, denotes the extent to which coordination within a company is centralized or decentralized. In some companies a centralized unit is responsible for coordinating product information sharing (Boukef Charki et al. 2011), in others several roles or organizational units coordinate product information sharing (Schäffer and Stelzer 2017). Typical examples are MDM teams and sales or procurement departments (Legner and Schemm 2008).

When identifying actors involved in product information sharing it also became clear that relevant papers identify two categories of actors. Some papers take a macro-perspective and distinguish data suppliers (or senders or providers) (Boukef Charki et al. 2011), data consumers (or receivers) (Legner and Schemm 2008), and intermediaries (or data service providers), e.g., providers of data pools or data services (Ginet 2014). We call this dimension **supply chain actors**. Other authors take a micro-perspective and describe actors involved in product information sharing within organizations. We call this dimension **corporate actors**. The most frequently reported actors are sales departments (in data supplying organizations) and procurement departments (in data consuming organizations) (Legner and Schemm 2008), MDM teams (Madlberger 2011b), and IT departments, although IT staff seem to be of minor importance for the inter-organizational synchronization of product master data (Schäffer and Stelzer 2017).

We identified several **activities** that are performed or suggested to establish efficient product information sharing processes. Data quality requirements involve defining requirements for product master data to be provided by data suppliers, e.g., accuracy, consistency, completeness, timeliness (Falge et al. 2012). Data exchange denotes transferring and synchronizing product data from data suppliers to data consumers (Legner and Schemm 2008; Schäffer and Stelzer 2017). Data validation involves evaluating and ensuring that product data provided by data suppliers meet specified quality criteria (Madlberger 2011a). Feedback involves creating an evaluation report stating the results of data validation. This report is provided to the data supplier in order to help him improve product data quality (Dalmolen et al. 2015).

Iteration 1 distinguished corporate, team, and individual **goals**. Literature on product information sharing describes various corporate goals (Legner and Schemm 2008; Datta and Christopher 2011; Ibrahim and Nicolaou 2011; de Corbière and Rowe 2013; Tengberg 2013; Schäffer and Stelzer 2017). However, team and individual goals are seldom reported, although some papers emphasize that sales and procurement staff pursue targets that are not necessarily compatible with efficient product information sharing (Le Dû and de Corbière 2011; Schäffer and Stelzer 2017). Instead, we identified four categories of goals in the papers covered by our literature review (Koçoğlu et al. 2011; Le Dû and de Corbière 2011; Madlberger 2011a): Social goals denote objectives relating to the social relationship of data supplier and data receiver, e.g., improving personal relations of contact persons, trust building, or reduction of uncertainty. Technical, goals are objectives relating to technical readiness for product information sharing. Legal goals relate to compliance with legal obligations. Economic goals denote objectives relating to economic values, e.g., improving customer satisfaction, reducing costs, securing or increasing turn over, etc.

Some papers take different **perspectives on actors** involved in product information sharing. Some papers implicitly assume that coordination is managed by a single imaginary decision maker (Cai and Shankaranarayanan 2004; de Corbière and Rowe 2010a, 2010b, 2013). Other papers take a team perspective and emphasize the existence of several units who take on different roles in coordination (Legner and Schemm 2008; Hüner et al. 2011;). Some papers describe self-interested coordination agents pursuing personal objectives (Legner and Schemm 2008; Schäffer and Stelzer 2017).

In iteration 1 we identified three types of **interdependencies**, pooled, sequential, and reciprocal. However, in the literature we found only two types: pooled and sequential interdependencies (de Corbière and Rowe 2010b; Madlberger 2011a, 2011b; Ginet 2014). Reciprocal interdependencies do not seem to be existent in product information sharing or they have not been identified and described.

Coordination problems are reported by several authors (Ibrahim and Nicolaou 2011; Madlberger 2011a; Schäffer and Stelzer 2017). These problems are closely connected to interdependencies. They more specifically describe problems that arise from inefficient product information sharing processes. The most frequently reported coordination problems are missing data, incorrect data, inadequate formats, and delayed data delivery (Hüner et al. 2011).

Some papers also identify **causes for coordination problems**. We grouped theses causes into the following classes: lack of interoperability (i.e., IT systems used for data transfer are not compatible), missing or inadequate data quality requirements (i.e., data quality requirements are not existent, not documented, not complete, or inadequate), missing or inadequate internal communication (i.e., missing or inadequate communication of sales/procurement staff, master data experts, and IT personnel), lack of skills and knowledge (i.e., lack of knowledge relating to MDM or master data quality), inappropriate technical readiness of trading partners (i.e., cooperation partners do not fulfil technical qualifications for product information sharing), and disregard of guidelines (i.e., business units do not comply with company-wide guidelines and internal standards for data quality) (Le Dû and de Corbière 2011; Madlberger 2011a, 2011b; Ginet 2014).

Differing from the categorization of **coordination mechanisms and tools** in iteration 1, we identified four types of mechanisms and tools for coordinating product information sharing in the literature. Inter-organizational systems involve IT resources shared between two or more organizations and supporting product information sharing, e.g., supplier portals, customer portals, or online product catalogs (de Corbière and Rowe 2010a, 2010b, 2013). Standardization consists of pre-definition and codification of inputs and outputs of master data transfer. Examples of such standards are EDI standards, identification and classification standards, and standards defined by data pools (Ginet 2014; Dalmolen et al. 2015). Bilateral agreements are mutual arrangements of cooperation partners documented in framework contracts or data quality guidelines (Falge et al. 2012; Schäffer and Stelzer 2017). Mutual adjustment denotes on-going adjustments to manage interdependencies using spreadsheet files, E-Mail, fax, telephone, etc. (Madlberger 2011a).

In addition to the concepts described in iteration 1, we identified another concept in the literature: cost of product information sharing. Authors exploring **cost of product information sharing** distinguish three cost categories. Personnel costs involve costs for staff members supporting preparation, implementation, and maintenance of product information sharing. License fees for software denote fees for software tools supporting product information sharing, Examples for fees for external services are monthly fees for data pools or data service providers (Madlberger 2011a).

3.4.3 Creation of Revised Taxonomy (Iteration 2)

Table 2 presents findings of our review of literatures focusing on product information sharing. It shows dimensions, characteristics, and descriptions of concepts that were discussed in the relevant papers.

Dimension	Characteristic	Description
Type of inter-organizational relationship	dyadic network	involves product information sharing between two organizations (1:1)
	multiple dyadic network	involves product information sharing of one organization with several others (1:n or m:1)
	many-to-many network	several organizations share product information with several other organizations (m:n)
Supply chain coordination structure	centralized	a centralized unit is responsible for coordination and uses global information for decision-making
	decentralized	decentralized units are responsible for coordination and use local information for decision-making
Corporate coordination structure	centralized	a single role or organizational unit coordinates product information sharing
	decentralized	several roles or organizational units coordinate product information sharing
Supply chain actors (macro-perspective)	data supplier	entity which produces and sends data
	data consumer	entity which receives and consumes data
	intermediaries	providers of data pools or data services
Corporate actors (micro-perspective)	sales/procurement dpt.	unit responsible for selling products/ services (sales) or obtaining goods/services (procurement)
	MDM team	unit responsible for MDM, either for the entire company or for local or functional departments
	IT dpt.	unit that establishes, maintains and provides IT services and the IT infrastructure
Activities	requirements definition	definition of quality criteria for product master data
	data exchange	exchange, transfer, or synchronization of product data between data supplier and data consumer
	data validation	evaluating and ensuring that product data provided by data suppliers meet specified quality criteria
	feedback	involves creating an evaluation report stating the results of data validation
Goals	social	objectives relating to the social relationship of data supplier and data consumer
	technical	objectives relating to technical readiness for product information sharing
	legal	objectives relating to compliance with legal obligations
	economic	objectives relating to economic values
Perspective on actors	single-person	assumes that coordination is managed by a single decision maker
	team	emphasizes the existence of several units who take on different roles in coordination
	nexus-of-contract	assumes self-interested coordination agents pursuing personal objectives
Interdependencies	pooled	activities share or produce common data but are otherwise independent
	sequential	some activities depend on the completion of others before beginning
Coordination problems	missing data	some data were not transferred from the data supplier to the data consumer
	incorrect data	some data are not correct and do not meet specified requirements
	inadequate format	data format does not meet specified requirements
	delayed data delivery	data were transferred but not in time
Causes for coordination problems	lack of interoperability	IT systems used for data transfer are not compatible
	missing or inadequate data quality requirements	data quality requirements are not existent, not documented, not complete, or inadequate
	missing or inadequate internal communication	missing or inadequate communication of sales/procurement staff, master data experts and IT staff
	lack of skills and knowledge	lack of skills and knowledge relating to MDM or master data quality
	inappropriate technical readiness of trading partners	cooperation partners do not fulfil technical qualifications for product information sharing
	disregard of guidelines	business units do not comply with company-wide guidelines and internal standards for data quality
Coordination mechanisms and tools	inter-organizational systems	involves IT resources shared between two or more organizations
	standardization	consists of pre-definition and codification of inputs and outputs of master data transfer
	bilateral agreement	mutual arrangements of partners documented in framework contracts or data quality guidelines
	mutual adjustment	on-going adjustments to manage interdependencies using E-Mail, fax, telephone, etc.
Cost of product information sharing	personnel cost	cost for staff members supporting product information sharing
	license fees for software	fees for software tools supporting product information sharing
	fees for external services	fees for external services e.g., monthly fees for data pools or data service providers

Table 2: Taxonomy of inter-organizational product information sharing after iteration 2

3.5 Evaluation

We subdivided the last step of the taxonomy development into three substeps: evaluation in expert interviews, creation of revised taxonomy (iteration 3), and evaluation against ending criteria.

3.5.1 Evaluation in Expert Interviews

First, we evaluated the taxonomy (iteration 2) by interviewing experts in product information sharing. The selection of interview partners was mainly driven by two criteria: extensive firsthand experience in product information sharing and availability and willingness to participate in an interview. We discussed iteration 2 with one scholar and two practitioners. Our first interview partner is a professor in business and information systems engineering at a European university, with broad research experience in product information sharing. The second interviewee is an IT manager at a major European wholesale trading company with university degrees in linguistics and computer science and several years of experience in exchanging master data with suppliers and customers. Our third interview partner is a member of an MDM team at a large retail company. He has more than ten years of experience with MDM relating to ERP systems and in product information sharing. In the interviews, we discussed the following questions: Is the taxonomy adequate and complete? Are all relevant objects included in the taxonomy? Would you suggest modifying the taxonomy? Which dimensions and characteristics should be deleted? Which dimensions or characteristics should be added?

The IS professor was familiar with understanding and discussing taxonomies. However, the practitioners were not used to evaluating taxonomies. We therefore asked them to describe whether and to what extend the dimensions and characteristics are applicable in their companies. We asked them to describe each dimension in their own words and to give examples for characteristics from their own personal experience. If the interview partners were able to give descriptions and examples we interpreted this as a sign of understanding and applicability of the taxonomy. We summarize key findings of the expert interviews:

- The overall evaluation result of all interviews was that the taxonomy is **comprehensible and useful**.
- However, the practitioners had difficulties in understanding the concept of **interdependencies**. We discussed this in detail and came to the conclusion that the dimensions interdependencies, on the one hand, and coordination problems and causes for coordination problems on the other hand implicitly reflect the same objects. We therefore deleted the dimension interdependencies from iteration 3.
- Some of the **labels** for dimensions may not be comprehensible for practitioners. As a consequence, we renamed the dimensions coordination problems and causes for coordination problems to data synchronization problems and causes for data synchronization problems. Labels for the characteristics single-person, team, and nexus-of-contract perspective (dimension perspective on actors) may be misleading or difficult to understand. We therefore renamed these characteristics to corporate, team, and individual perspective. Feedback (dimension activities) was renamed to continuous improvement as feedback is only one element of continuous improvement of product information sharing.
- The interview partners were of the opinion that the taxonomy needs a **clearer distinction of intra-organizational and inter-organizational objects**. We therefore decided to rename four dimensions: supply chain and corporate coordination structure in iteration 2 were renamed to inter- and intra-organizational coordination structure in iteration 3 and supply chain and corporate actors in iteration 2 were renamed to inter-/intra-organizational actors in iteration 3.
- The following **characteristics were added**: hybrid coordination structures (in the dimensions inter-organizational coordination structure and intra-organizational coordination structure) and initiating product information sharing (in the dimension activities). Initiating product information sharing involves agreeing to share product data and creating the necessary prerequisites for data synchronization. Our interview partners also emphasized that a new activity should be added that we called negotiating technical details of master data transfer. This involves agreements on networks, services, formats, and data structures for data transfer from data suppliers to consumers.
- The **causes for data synchronization problems** (named causes for coordination problems in iteration 2) should be structured into classes. Together with our interview partners we structured the problems into four classes: intra-organizational (i.e., issues resulting from problems within an organization, e.g., missing or inadequate internal communication or alignment of business units), inter-organizational (i.e., issues resulting from problems between organizations, e.g., missing or

inadequate external communication, very different corporate cultures, unequal distribution of power, missing alignment with service providers), personnel (i.e., lack of technical or social skills), and technical causes (i.e., deficiencies relating to interoperability, data quality requirements, tools, etc.).

- The interview partners mentioned **two more cost categories**: hardware costs, e.g., for IT infrastructure and data storage systems, and cost of data, e.g., data supplied by external providers.
- A **mapping between activities and actors** could further enhance the informative value and explanatory power of the taxonomy. As the form of presentation of our taxonomy makes it difficult to express relationships, we decided to leave this improvement suggestion for future research.

3.5.2 Creation of Revised Taxonomy (Iteration 3)

Although we present the creation of the revised taxonomy in one step, we actually performed three sub-iterations. After we had interviewed the first expert and analyzed the interview findings, we revised iteration 2 (presented in table 2) to iteration 2'. We used this iteration as input for the second interview. We proceeded in the same manner after the second interview. Due to space limitations, we cannot present iterations 2' and 2'' here. Table 3 shows iteration 3 of the taxonomy that was created after all interview findings had been analyzed and consolidated.

Dimension	Characteristic	Description
Type of inter-organizational relationship	dyadic network	involves product information sharing between two organizations (1:1)
	multiple dyadic network	involves product information sharing of one organization with several others (1:n or m:1)
	many-to-many network	several organizations share product information with several other organizations (m:n)
Inter-organizational coordination structure	centralized	a centralized unit is responsible for coordination and uses global information for decision-making
	decentralized	decentralized units are responsible for coordination and use local information for decision-making
	hybrid	combination of centralized and decentralized inter-organizational coordination structures
Intra-organizational coordination structure	centralized	a single role or organizational unit coordinates product information sharing
	decentralized	several roles or organizational units coordinates product information sharing
	hybrid	combination of centralized and decentralized intra-organizational coordination structures
Inter-organizational actors	data supplier	entity which produces and sends data
	data consumer	entity which receives and consumes data
	intermediaries	providers of data pools or data services
Intra-organizational actors	sales/procurement dpt.	unit responsible for selling products/ services (sales) or obtaining goods/services (procurement)
	MDM team	unit responsible for MDM, either for the entire company or for local or functional departments
	IT department	unit that establishes, maintains and provides IT services and the IT infrastructure
Activities	initiating	agreement to share product data and creation of necessary prerequisites
	requirements definition	definition of quality criteria for product master data
	negotiating technical details of master data transfer	negotiating technical details of master data transfer from data supplier to data consumer (networks, services, formats, data structures, etc.)
	data exchange	exchange, transfer, or synchronization of product data between data supplier and data receiver
	data validation	evaluating and ensuring that product data provided by data suppliers meet specified quality criteria
	continuous improvement	involves creating an evaluation report stating the results of data validation. This report is provided to the data supplier in order to help him improve product data quality
Goals	social	objectives relating to the social relationship of data supplier and data receiver
	technical	objectives relating to technical readiness for product information sharing
	legal	objectives relating to compliance with legal obligations
	economic	objectives relating to economic values
Perspective on actors	corporate	assumes that product information sharing is managed by a single decision maker
	team	emphasizes the existence of several units who take on different roles in product information sharing
	individual	assumes self-interested individuals, each maximizing his or her personal objective
Data synchronization problems	missing data	some data were not transferred from the data supplier to the data receiver
	incorrect data	some data are not correct and do not meet specified requirements
	inadequate format	data format does not meet specified requirements
	delayed data delivery	data were transferred but not in time
Causes for data synchronization problems	intra-organizational	issues resulting from problems within an organization
	inter-organizational	issues resulting from problems between organizations
	personnel	lack of technical and social skills
	technical	deficiencies relating to interoperability, data quality requirements, tools, etc.
Coordination mechanisms and tools	inter-organizational systems	involves IT resources shared between two or more organizations
	standardization	consists of pre-definition and codification of inputs and outputs of master data transfer
	bilateral agreement	mutual arrangements of partners documented in framework contracts or data quality guidelines
	mutual adjustment	on-going adjustments to manage interdependencies using E-Mail, fax, telephone, etc.
Cost of product information sharing	personnel cost	cost for staff members supporting product information sharing
	license fees for software	fees for software tools supporting product information sharing
	hardware costs	cost of hardware, infrastructure, and data storage supporting product information sharing
	cost of data	fees for data supplied by external providers, e.g., address data
	fees for external services	fees for external services, e.g., monthly fees for data pools or data service providers

Table 3: Taxonomy of inter-organizational product information sharing after iteration 3

3.5.3 Evaluation against Ending Criteria

Finally, we evaluated the taxonomy against the ending criteria. First, we discussed the subjective ending criteria with our interview partners. Second, on completion of iteration 3, we assessed whether and to what extent our taxonomy meets the objective ending criteria.

Our taxonomy is concise, robust, extendible, and explanatory. It is compatible with coordination theory and comprehensible for scholars and practitioners. Our interview partners described it as useful. It consists of dimensions each with mutually exclusive and collectively exhaustive characteristics. No object was merged with a similar object or split into multiple objects in the last iteration. At least one object is classified under every characteristic of every dimension. Every dimension and every cell is unique and not repeated. Every characteristic is unique within its dimension.

Two questions remain: Is the taxonomy comprehensive? Does it provide for the classification of all current objects relevant for product information sharing? Neither our literature review nor the expert interviews led to more objects than presented in the taxonomy. However, we cannot exclude that interviews with more experts could lead to more dimensions and/or characteristics. We leave this for future research. However, we are confident that the taxonomy presented in this paper provides a helpful basis both for scholars and for practitioners specializing in product information sharing.

4 CONCLUSION

We have developed and evaluated a taxonomy that enables a clearer conceptualization of coordinating quality of master data in product information sharing than we have had before. It allows us to describe and to analyze issues and to distinguish options for resolving problems in this domain. Development and evaluation of the taxonomy is based on a method suggested by Nickerson et al. (2013). It helped us to identify key concepts and characteristics of product information sharing and to discuss these concepts with practitioners who are experts in managing data quality when synchronizing product master data across companies. Our taxonomy meets the evaluation criteria suggested by Nickerson et al. (2013). Moreover, it is compatible with coordination theory and with previous research into product information sharing. Our interview partners assessed it as comprehensible and useful.

Our study has several limitations: First, we have not considered intra-organizational issues of ensuring and improving quality of product master data although challenges and possible improvements of inter- and intra-organizational aspects of coordinating quality of master data in product information sharing are closely intertwined. Second, the taxonomy is limited to the process of product information sharing and does not include for example quality of product information, or tools for defining, storing, or transferring product information. Third, as Nickerson et al. (2013) have pointed out the approach to taxonomy development used in this paper may lead to useful, but not necessarily to optimal solutions. Completeness of dimensions and characteristics of the taxonomy may be an issue. More intensive research into the process of improving quality of product master data in inter-organizational settings might lead to more elements of the process of coordinating quality of master data in product information sharing.

We hope that our paper will stimulate future research into master data quality when synchronizing product master data in inter-organizational settings. There are a number of interesting extensions for future research. One area is to further assess the comprehensibility of the taxonomy, for example, by asking more scholars and practitioners to evaluate the taxonomy. We encourage research into international settings of product information sharing, a research field that we have not explicitly taken into account. International companies with foreign branches, subsidiaries, suppliers, and customers might wish to include more dimensions or characteristics than included in the current version of the taxonomy. We used tables to represent the taxonomy. Future research could assess other forms of representation, e.g., graphs displaying semantic networks. This would allow for representing relations between concepts, dimensions, and characteristics included in the taxonomy. A mapping between activities and actors, for example, could further enhance the informative value and explanatory power of the taxonomy.

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