



Applying activity-based costing in a supply chain environment

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ABSTRACT

Traditional intra-firm cost accounting tools are not appropriate in the context of supply chain management, as there are no standards for the definition and composition of costs. This prohibits exchange and comparison of cost data among different supply chain members. Against this background, several activity-based costing models for inter-firm cost accounting have been proposed. Evaluating these models, a conceptual framework for activity-based costing in a supply chain has been developed. This also forms the basis for a single case study conducted at Europe's largest company for façade components. This demonstrates how significant inter-firm cost saving opportunities can be identified and offers a first step in assessing the suitability of the proposed model.

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1. Introduction

In the course of the lean manufacturing movements in the early 1990s, optimisation programs were carried out, which mainly focussed on intra-firm specific processes (Jones et al., 1997). Besides concentrating on core competencies, one major reason was to reduce a company's own contribution to a product's value by outsourcing up to 70% of it to outside suppliers (McCarthy and Anagnostou, 2004). Such increased outsourcing of functions has put high demands on the coordination of activities within the supply chain. It is necessary to align inter-company material- and information-flows in order to meet market demands, e.g. to react flexibly in the sense of product functions, demand fluctuations or new delivery service requirements. Therefore, coordination is defined as a method to secure the effective and efficient combination of various firm-specific competencies with regard to manifold objects (information, actions, decisions, goals, etc.) (Simatupang et al., 2002). In line with this a debate on supply chain integration has emerged (see e.g. the review in Van der Vaart and van Donk, 2008).

Low total costs are frequently considered as a typical operational goal for supply chain management, asking for the application of cost management tools as “obvious” candidates (Mouritsen et al., 2001; Israelsen and Jørgensen, 2011). They are regarded as an impartial criterion for the evaluation of the profitability of strategic or operational action. Such information is usually available on an intra-company level, as it can be generated by intra-firm cost accounting tools (Askarany and Yazdifar, 2011). The coordination of a supply chain calls for an inter-firm accounting tool to secure the effective

and efficient coordination of the value chain (LaLonde and Pohlen, 1996). This holds for the introduction of a completely new supply chain strategy as well as for the optimisation of certain processes (Seuring, 2009). Managers must be able to effectively assess in advance the cost consequences of any supply chain or process reconfiguration. Therefore, companies need inter-company cost accounting tools (Seuring, 2002a; Cooper and Slagmulder, 2004). These tools should enable them to assess costs based on a predetermined set of basic cost accounting standards in order to guarantee objective and rational decisions (LaLonde and Pohlen, 1996). Only a detailed assessment at every level of the supply chain allows distributing costs and benefits equally along the supply chain and leads, finally, to the “optimal” configuration of the supply chain network.

Due to the practical relevance of inter-firm cost accounting standards, some researchers have taken up these preconditions and have developed conceptual models for cost accounting in supply chains. Many of these considerations are based on activity-based costing as a related cost management technique (for a critical look at its status of implementation see Askarany and Yazdifar, 2011). However, such approaches concentrate on certain aspects of supply chain management and respective performance measures, only. Often, they concentrate just on efficiency increases in existing two-tier partnerships (see e.g. the literature review section in Zimmermann and Seuring, 2009). In doing so, such activity-based costing models leave considerations regarding an effective network set-up and spreading of production activities outside their scope, form a one of a kind approach and do not deal with how to integrate and compare different company accounting standards in one activity-based costing model (as discussed in the literature review).

Therefore this research approach focuses on the possibilities and limitations inherent in activity-based costing methodology for inter-firm cost accounting. The underlying inductive assumption is that

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by picking up theoretical insights existing models could be falsified, verified or modified by practical insights resulting in a new comprehensive framework.

Therefore the research questions can be formulated as follows: (1) How can activity-based costing in a supply chain be conceptualised in line with typical aims of an effective configuration and operation of the supply chain? (2) What (explorative) insights can be gained towards the validity of such an activity-based costing application in a supply chain based on a single case study?

This leads to the following structure of the paper, which comprises two major parts. The first section summarises previous research on inter-firm activity-based costing. Reflecting on these demands supply chain management places on inter-firm cost accounting, preliminary ideas about the design of such cost management systems are outlined. Based on this a conceptual activity-based costing model for the context of supply chain management is developed. Within the second part, these ideas are tested in a case study, which was conducted at a Germany based leading producer of façade components. This will be presented and discussed against the theoretical background developed in the first part. The paper concludes with a critical reflection on the findings by discussing the chances and limitations of inter-firm activity-based costing.

2. Literature review

2.1. Overview of activity-based costing models for supply chain management

Activity-based costing and its application in manufacturing environments have been widely discussed (e.g. Wouters, 1994; Gunasekaran and Sarhadi, 1998; Thyssen et al., 2006; Askarany and Yazdifar, 2011; Israelsen and Jørgensen, 2011). There are many examples in production management related decision, such as holding cost determination (Berling, 2008), decoupling point related decisions (Özbayrak et al., 2004), transport (Lin et al., 2001; Baykasoğlu and Kaplanoğlu, 2008) or distribution logistics (Pirttilä, Hautaniemi, 1995), product design (Tornberg et al., 2002; Ben-Arieh and Qian, 2003; Qian and Ben-Arieh, 2008), product modularity (Thyssen et al., 2006), product-mix decisions (Kee and Schmidt, 2000), production learning (Andrade et al., 1999) or process reengineering (Tatsiopoulos and Panayiotou, 2000) just naming a few ones. In the following paragraph, an overview of recent contributions regarding the development and application of activity-based costing models in the context of supply chain management is presented. Accordingly the contributions of LaLonde and Pohlen (1996); Dekker and van Goor (2000); Seuring (2002a, 2002b), Möller and Möller (2002), Bacher (2004) and Pohlen and Coleman (2005) are presented in the sequence of their publication. This list comprises all major contributions at the intersection of activity-based costing and supply chain management, but are limited to such ones, where emphasis is placed on the overall supply chain, not just a selected decision or issue within it. For the purpose of this paper, it seems more appropriate and relevant to discuss these contributions in detail than outlining a wider range of literature.

One of the early contributions that also coined the term “supply chain costing” is the paper by LaLonde and Pohlen (1996). In their paper, they point to the use of activity-based costing and outline a six step process for managing costs across a supply chain. Their approach stays on a normative level where it is neither discussed how it can be applied, nor is an example provided.

Dekker and van Goor (2000) present a case study conducted in the Dutch pharmaceutical industry. It describes the cost-effective optimisation of a three echelon supply chain (manufacturer—wholesaler—retailer). Their model focuses on logistical activities and the total supply chain costs are calculated by adding up the

total activity-based costs of each company. The core principle of this model is a joint definition of activities and cost drivers in order to determine the cost-effective consequences of any process reconfiguration. Dekker and van Goor (2000) note that their model is only applicable for rough calculation of cost effects. Nevertheless, its power is described in a case study where the effect of inventory relocation from the manufacturer to the wholesaler is evaluated.

Reflecting thoughts on transaction cost economics, and based on the insights of LaLonde and Pohlen (1996); Seuring (2002a) presents a three step approach to activity-based costing in supply chains. The first step “inter-company integration of process modelling” describes a top-down process analysis based on the SCOR model (Stewart, 1997). Through a collaborative development of a unified process definition and, further, through a separation of costs into direct, process (activity-based), and transaction costs, it is possible to allocate costs to the different process steps and to model several process options. The second step “analysis of cost origins” of Seuring’s model aims at assessing which of the identified process costs could be modified by the company on its own, and which of the transaction cost elements are influenced by inter-company decisions. Seuring (2002a) proposes a collaborative allocation of costs to the determined cost drivers, which forms a starting point for the third step “identification of cost modification opportunities”. As the developed process scheme and underlying cost allocation is too complex to optimise all factors at once, the defined processes and cost drivers can be used to evaluate trade-offs. In doing so, it is possible to assess different supply chain design decisions regarding their cost effectiveness. Consequently, managers can assess the total costs of any supply chain modification. Seuring (2002b) explains the application of his model by a case study carried out in the apparel industry. It is shown how a reduction of colours of a textile producer leads to a significant reduction of supply chain costs, both for the textile producer and for the downstream apparel manufacturer.

Möller and Möller (2002) show how suppliers are integrated in the product development process based on an activity-based analysis of the total costs of supply. Activity-based costing information is used for pre-development budgeting purposes. This allows a determination of costs during product development and, finally, an evaluation of the performance of the suppliers. This is demonstrated in a case study conducted at ZF Friedrichshafen AG, a major supplier of the automotive industry. Möller and Möller (2002) calculate process costs using the standard activity-based costing methodology. Based on a three-staged process scheme, cost driver information is summed up to calculate product costs according to the necessary production processes (drilling, tempering, etc.). These costs serve as a target for determining a cost effective product structure and thus in selecting appropriate suppliers and supply chain structure.

Bacher (2004) picks up the conceptual model of Seuring (2002a) and criticises that it implicitly presumes the application of intra-company activity-based costing on an inter-company level. Moreover, he questions whether every company is willing to share sensitive cost information (Mouritsen et al., 2001). Against this background, he proposes a three-stage model in order to facilitate an inter-company quantification of cost information. Companies at the first stage jointly carry out process mapping initiatives and collaboratively identify cost drivers for every process activity. Based upon these definitions, process optimizations are elaborated and judged aiming to improve supply chain efficiency. On the second stage, companies assign cost information to the identified cost drivers in order to assess and optimise process performance. However, this is only carried out irregularly and based on a specific demand. In contrast, on the third stage, routines are developed to assign and exchange cost information continually.

Pohlen and Coleman (2005) propose a framework in which activity-based costing is used to quantify the considerations of an economic value added (EVA) analysis in terms of costs. After collaboratively establishing strategic objectives for the supply chain and jointly mapping supply chain activities, a dyadic EVA analysis offers insights into how process changes drive value, and thus aligns operations performance with supply chain objectives. Pohlen and Coleman (2005, p.52) state that by “incorporating all of the drivers of shareholder value, managers can move beyond cost–cost discussions, where one firm “loses” and another “wins”, to identify inter-firm opportunities that create value for both firms and the entire supply chain”. However, they continue: “successful inter-firm collaboration will directly depend on the ability to accurately measure and assign any resulting cost changes”. This task is taken over by activity-based costing, which links value drivers and financial measures of the EVA-analysis with the associated operational measures. Activity-based cost drivers are used to translate intra-firm non-financial changes in operational performance of any activity into costs and, subsequently, into financial performance. In doing so, activity-based costing information is translated into assignable costs that can be applied to the particular partner being studied. However, as with the model of Bacher (2004), considerations regarding supply chain effectiveness are not taken into account as supply network is seen as a given fact.

It also has to be mentioned, that some papers, which use the term “supply chain costing” are very restricted in scope. Lin et al. (2001) just look at transport issues and are hence already listed above. As the overall just deal with logistics costs, their approach is much narrower than those already mentioned.

2.2. Analysis of the presented activity-based costing models

When concerned with the conceptual design of integrated cost accounting tools and practices, researchers have not only to consider the intended use of cost information, but the structure of the supply chain as well (Gulati and Singh, 1998).

There are various supply chain management integration models (see e.g. Stevens, 1989; Bechtel and Jayaram, 1997; Mentzer et al., 2001; Van der Vaart and Van Donk (2004)). Cooper and Slagmulder, 2004 showed that those models can be distinguished into two categories. One group of authors is focussing on the product dimension of supply chain management whereas the other group focuses on its relationship dimension. Seuring (2009) takes up both dimensions and integrates them into the product-relationship-matrix, which he justifies against operations' strategy and supply chain design literature. This framework is useful to analyse the conceptual cost models presented as it provides a summary of related decisions to be made in designing and operating a supply chain. As briefly outlined, we therefore give a short overview of this framework. Building on life-cycle thinking, the dimensions are separated into two categories. The product dimension is split up into the phases of (1) product design (pre-phase), (2) production and logistics (market phase). The relationship dimension is split up into configuration (network design) and operation. In the first field “strategic configuration of product and network”, decisions are made concerning the kind of products and services that are offered and with which supplier a company is willing to cooperate. The second field “product design” is concerned about utilising the research and development know-how of the chosen suppliers. “Formation of the production network” covers the allocation of the specific production processes to each of the companies of the supply chain, and the decision on the related decoupling points. The fourth field targets efficiency increases, e.g. in terms of automation of technical processes or information technology. Summing up, tasks in

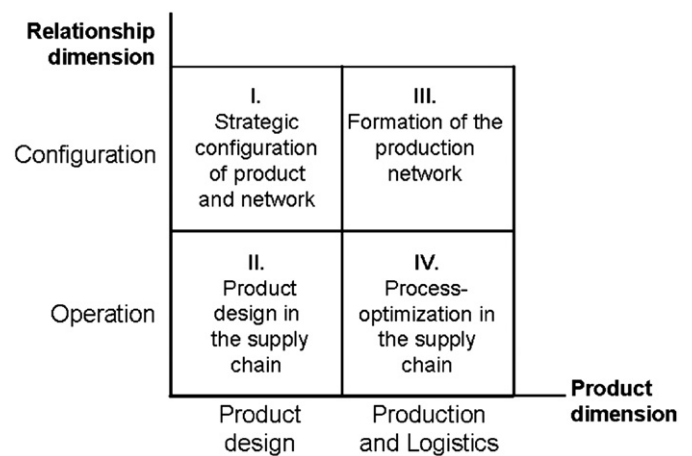


Fig. 1. The product-relationship-matrix of supply chain management (simplified from Seuring, 2009, p. 5).

the first and third field aim to achieve an effective supply chain design, whereas the second and fourth field focus on increasing operational efficiency (Fig. 1).

This framework can be used for analysing the activity-based costing models presented above. Therefore, the following criteria will be used, which are briefly explained:

As one major aspect, the supply chain configuration (network design in Fields I and III) is assessed:

- (1) The length of the chain (dyadic or multi-level (tier) supply chain), which indicates the number of company specific cost accounting systems and information have to be analysed and thus integrated in the activity-based model. Much research on supply chain management rather centres on focal companies for data collection (Seuring, 2008).
- (2) The kind of business relationship (hierarchical vs. heterarchical coordination) (Hülsmann et al., 2008), as this influences the reluctance to share process and cost information. Thus activity-based models have to be applicable to the different types of coordination. However, most supply chain research just assumes that a focal company would be the main coordinator.
- (3) The content of the business relationship (kind of processes, products, etc.) are common parameters for structural analysis (e.g. Childerhouse et al., 2002).
Analysing on how the activity-based costing models shown deal with the intended use of cost information, parameters to measure efficiency increases have to be taken into account during operation (Fields II and IV). Related criteria are the following:
- (4) Standardized algorithms and data bases should be available to allow for supply chain-wide cost transparency.
- (5) Timely availability allowing continuous analysis of cost information (Mouritsen et al., 2001). Both (4 and 5) require that an established cooperation among suppliers and customers is in place, so that open book accounting practices would be established.
- (6) Along with this, conceptual cost models must be customizable to individual supply chain structures and circumstances. Hence it is assessed, whether case study related research has been presented, where all papers present single case studies anyway. This is well in line with recent papers analysing empirical case based research in supply chain management and all demand more research on longer part of it (Dubois and Araujo, 2007; Hilmola et al., 2005; Seuring, 2008).

Table 1

Comparison of previous research contribution to activity-based costing in supply chain management.

Criteria for model analysis		LaLonde and Pohlen (1996)	Dekker/van Goor (2000)	Seuring (2002a, 2002b)	Möller and Möller (2002)	Bacher (2004)	Pohlen and Coleman (2005)
Design for Cost Effectiveness	(1) Chain length > 2 companies	(X)	X	X			
	(2) Content of business relationship (others than logistical functions)	X		X	X		X
	(3) Kind of business relationship						(X)
Optimization for Cost Efficiency	(4) cost transparency standards (X)/collaboratively defined standard chart of accounts (Y)	X	X	Y	Y	X	X
	(5) possibilities for ongoing, real-time data evaluation	X			X		
	(6) Empirical evidence from a single case study		X	X	X		

Table 1 summarises how the contributions dealt with the described criteria. The comparison of the identified characteristics of the conceptual activity-based models for supply chain management indicates that authors have focused on a selected range of the criteria necessary to develop a comprehensive activity-based costing approach, which would be applicable in a supply chain.

1. Chain length—focus on dyadic relationships:

Irrespective of the debate on supply chain management, if a supply chain is constituted by two or more independent companies, many authors inherently “limit” their conceptual designs to dyadic relationships (Möller and Möller, 2002; Bacher, 2004; Pohlen and Coleman, 2005). However, in today’s global supply chain there are often more than two companies involved: the supplier, at least one logistics service provider, the manufacturer, the retail sector and, of course, the final customer. Therefore analysing a dyadic relationship may be not far-ranging enough for supply chain cost analysis, as multi-scale effects can turn dyadic trade-off calculations upside down (Goldbach et al. 2003). Dekker and van Goor’s (2000) model focuses on a three-stage supply chain.

2. Content of business relationship:

However they concentrate only on one sort of process (logistical), as does the model of Bacher (2004). The model of Möller and Möller (2002) also mainly concentrates on one process—the product development process, just as Seuring’s (2002a) and Pohlen and Coleman’s (2005) conceptual models explicitly include all processes that contribute to a products value (e.g. product development, manufacturing, distribution, etc.).

3. Kind of business relationship:

As Table 1 indicated, the authors do not take the kind of supply chain relationship into account (Gulati and Singh, 1998). Yet, as outlined by Cooper and Slagmulder, 2004 in the Japanese automotive industry, it is especially the kind of business relationship, which determines the content and the kind of management accounting technique applied. Thus it is the kind of cooperation and its direction determining the applicability of the respective cost management approach.

4. Cost transparency standards and collaboratively defined standard chart of accounts:

Concerning the “Optimisation for Cost Efficiency” fields, all authors assume some kind of cost factor standardisation as a precondition for a supply chain-wide, activity-based costing approach. Dekker and van Goor (2000), Bacher (2004) and Pohlen and Coleman (2005) call for a collaborative definition of activity-based cost drivers. They argue that this approach reduces complexity and thus increases practicability. However, one drawback may be that although the cost drivers are collaboratively defined, the incorporated cost factors are not consistent. For that reason, Seuring (2002a) and Möller and

Möller (2002) claim a jointly developed standard chart of accounts.

5. Possibilities for ongoing, real-time data evaluation:

However, the practicability of such an approach depends on company size and the number of companies under consideration. Regarding the aspect of continuous data evaluation, no concrete advice is given. This aspect shows the major weakness of all conceptual models. This is inherent in the standard activity-based costing methodology. Regardless of the standard problem of a correct definition and allocation of activities to resources, data collection and processing is time consuming, particularly if products or processes are continually renewed. Summing up, a solution for an ongoing, real-time evaluation of huge amounts of data of different companies is not presented.

6. Empirical evidence from a single case study:

Last but not least, conceptual models have to be applicable to real supply chains. Dekker and van Goor (2000), Möller and Möller (2002) and Seuring (2002b) discuss the practical application of their models by presenting case-based evidence. Having shown some of the drawbacks of those concepts, it is evident that limited empirical research has been presented so far.

3. Model development

Reflecting the consensuses as well as the shortcomings of the various conceptual aforementioned models, the authors propose the following activity-based costing model for supply chain management (Fig. 2). This model comprises a two step approach. Whereas activities of the first step reflect requirements of the product design phase of the product-relationship-matrix (see Fig. 1), second step calculations give necessary input for the production phase. It is emphasised that these steps might have to be repeated, so that an iterative process results. Hence, the subsequent discussion presents an ideal sequence.

In the product design phase, a company has to decide the general supply chain strategy. Here, the product spectrum offered and the selection of adequate suppliers needs to be based on cost and performance information. Yet, such information would normally not be precisely available at this point in time. Product design as well as the business relationship might not already be completely defined. Therefore, in this phase, companies need a tool, which can transform cost considerations into (qualitative) performance measures to foster the decision process. In accordance with this, we propose the following procedure as described in the first step. For a start, a company should map its supply chain to a standard process description. This can be done, e.g. building on the SCOR model (Stewart, 1997). In doing so, attention should be paid to a rough description of the main (sub-)processes and their activities (boxes A

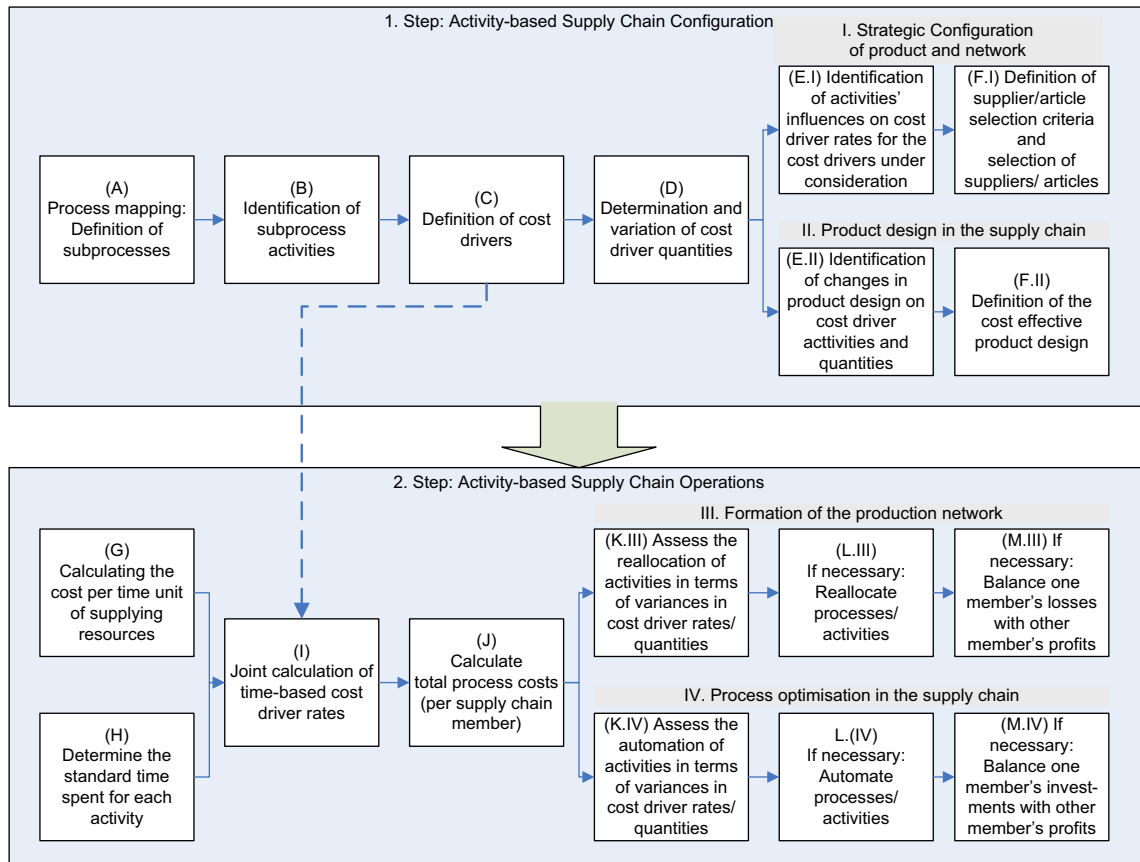


Fig. 2. Activity-based costing model for supply chain management.

and B, Fig. 2). This can be approximated on preliminary process investigations with potential suppliers. Based on this description, cost drivers are defined (C). According to activity-based costing methodology, these cost drivers form a comprehensive unit of workload reflecting the activities of one sub-process. Afterwards, estimated quantities are added to the cost drivers and variations are simulated (D). In doing so, companies become familiar with the cost-effective impact of the various sub-processes and activities (E). As a result, these insights are used to select suppliers, which conform to the demands of the network for overall cost effectiveness (field I of the product-relationship-matrix, see Fig. 1). Thus, knowing which activities have the main influence on the cost drivers, helps to develop a scheme with criteria for supplier selection (F), which is well in line with total cost of ownership (Ellram, 1995; Ellram and Siferd, 1998). Moreover, being able to simulate the influence of different product designs on activities and cost drivers (E & F), companies can decide on a cost-efficient product design (field II of the product-relationship-matrix, Fig. 1).

Having determined a cost-effective product spectrum and selected potential suppliers based on estimated variations in cost driver quantities, we propose to jointly calculate the rates of the defined cost drivers (I, Fig. 2). Thus, through calculating the exact costs of each sub-process, supply chain members also get to know about the costs of carrying out one activity (J). This offers a great opportunity to assess options for the reallocation of specific activities among the supply chain members (field III of the product-relationship-matrix, Fig. 1). For example, calculations may indicate that a significant amount of costs are spent for labelling boxes and scanning barcodes before, further downstream, a transponder is added. Based on these insights, it can be exactly calculated how the installation of a transponder further upstream

can reduce the costs of the downstream companies. As a result, a cost effective reallocation of activities is achieved. Besides, the unequal distribution of costs can be identified and balanced for overall supply chain effectiveness (K–M.III). The same holds true for increasing supply chain efficiency through e.g. automation of processes, which were previously carried out manually (K–M.IV, field IV of the product-relationship-matrix, Fig. 1). For example, if data is electronically exchanged through a standard compatible with the various enterprise-resources' planning systems in the supply chain, manual data entry could be eliminated. However, carrying out the second step of our model, companies are faced with the inherent complexity of an activity-based costing methodology in form of the top-down allocation of work-time capacities to the different activities. Therefore we propose making use of the time-driven activity-based costing approach as introduced by Kaplan and Anderson (2004). In this approach, cost driver rates are calculated bottom-up for each process element (Kaplan and Anderson, 2004). Therefore, managers estimate a standard time for carrying out one activity, e.g. picking a box out of a shelf takes two minutes (H). Afterwards the costs of supplying resources to this activity are calculated, e.g. one man-hour costs 20 € (G). The cost driver rate is calculated by multiplying the time needed for carrying out one unit of the activity with the costs of the resources supplied for this activity. This approach reduces much of the complexity inherent in traditional activity-based costing and is therefore also suitable for the context of supply chain management. Through the ease of calculation and time measurement, it can take different kinds of processes, process volumes or product variations into account. Moreover, as only costs for supplying process-related resources are measured, the fear of sharing cost information may be reduced as well.

4. Research methodology

According to Stuart et al. (2002), good theory is parsimonious, testable, and logically coherent. Thus the presented activity-based costing for supply chain management framework has to be proven by empirical research. Here, case study research forms a suitable approach, as it represents the intersection of theory, structures and events (Gubrium, 1988) and attempts to ground theoretical concepts with reality (Stuart et al., 2002). It allows the investigation of a specific phenomenon within its real environment through the use of different sources of knowledge. Based on the research process of Stuart et al. (2002), who propose a five-stage process for case study research, Seuring (2008) summarises criteria to be addressed in case study research (see Table 2). This is used here to provide basic information on the case study research conducted.

Reflecting the initial thoughts of this paper, the theoretical aim can be classified as an exploratory research. Exploratory research is suitable especially for research in new, relatively unsought research fields (Voss et al., 2002) where theory is still in its infancy, as is the case with activity-based costing in supply chains. This has, as summarised in the literature review, hardly been described so far. Therefore, exploratory research calls for an in-depth case study (Voss et al., 2002). Due to time and monetary reasons of data collection, they are often set up as a single case

Table 2
Case study research process.

Dimensions	Categories
<i>Stage 1: Research question</i>	
Theoretical aim	Exploration
<i>Stage 2: Instrument development</i>	
Case	In-depth case study of a 3-tier supply chain: BOSC is rarely implemented, if at all, then to modular products. How to apply principles to non-modular products?
Case selection	Extreme case: Supply Chain Redesign affecting production strategy and order-to-delivery process of three companies Revelatory case: Research in Supply Chain integration often suffers from a lack of empirical evidence.
<i>Stage 3: Data gathering</i>	
Data gathering techniques	<ul style="list-style-type: none"> ● Semi-structured interviews (62 in total, of which 23 were conducted with staff member outside the façade components manufacturer): <ul style="list-style-type: none"> – Extrusion moulder: Managing Director, Head of Production Department. – Wholesaler: Director of Logistics Worldwide, Director of Purchase, Director of Material Planning, Distribution Centres' Managers (Goods Receiving, Order Picking, Transport, Customer Service Centre), Head of Sales Department. – Surface coater: Managing Director, Head of Sales Department. ● Access to company internal documents. ● Direct observation. ● Participant observation
<i>Stage 4: Data analysis</i>	
Data analysis	Process diagrams with transaction analysis: Data was transcribed in flow charts backed up with a detailed description of procedures, documents and data for each identified process/activity.
<i>Stage 5: Dissemination/overall process</i>	
Case quality	Construct validity: ongoing access, several data collection methods External validity: Moderate complexity helped gather data Reliability: Transcription allowed data checkup by stakeholders

design. Here, a three-tier supply chain was selected. Implementing activity-based costing across several companies meant that heterogeneous factors had to be integrated into one single order-to-delivery-process; various production technologies had to be taken into account and, as a result, company-specific factors such as IT-systems and production facilities had to be restructured.

Case studies are often criticised for not being representative. However, this can be refuted by a detailed plan of how to carry out case study research, reflecting several activities to guarantee quality. In order to respond to construct validity, an on-going access to the research object (e.g. the supply chain and its companies) was one precondition. Several data collection methods were applied, in particular semi-structured interviews and document analysis. This form of methodological triangulation also met the reliability criterion to which any case study has to respond. By using many forms of data collection, discussing data within the project team and drawing process charts as a special form of case study protocol, it was possible to identify and validate information.

Concerning external validity, the moderate process complexity experienced during the case study enhanced validation and transfer of the identified build-to-order supply chain (BOSC) success factors in the non-modular order-to-delivery process. This even shortened the time needed for data collection, while such research in a more complex company network might soon become very complex and therefore almost impossible. The findings are presented below.

5. Case study findings

5.1. The focal company and the supply chain of the façade components manufacturer

The world's leading manufacturers for façade construction components (e.g. windows, doors, solar modules, conservatories) had a turnover of approximately 1.8 billion € in 2007 while employing 4600 employees. It does business in about 50 markets worldwide. Aluminium (as raw material) supply is provided by a range of suppliers and bought in a market transaction. Hence, the analysed supply chain consists of four stages, which are as follows: (1) extrusion moulding, (2) wholesaling, i.e. the façade components manufacturer, (3) surface coating and (4) final construction of components and façades (Fig. 3). The case company forms the focal company of the supply chain, as it develops and designs the final product, owns the brand name and organises the material and information flows among all other partners up and down the supply chain. In contrast, all production activities are outsourced to external partners.

The initial trigger was a change in the supply chain strategy from make-to-stock to build-to-order (Gunasekaran and Ngai, 2005). Related activity-based cost data was collected across the four stages of the supply chain involved in order to select the adequate partners and products, to reallocate functions, and to equally distribute the benefits of the new strategy. According to the described conceptual model, the supply chain was mapped using the SCOR model as a framework for standardized process description and data was collected of three tiers of the supply chain (see the highlighted boxes in Fig. 2). In this paper, the results that came from using the model in the supply chain configuration and operation phases of the product-relationship-matrix are presented.

5.2. (Re-)configuration of product and network

As stated, the main focus of this field of the product-relationship-matrix is to decide which product is to be produced and to select the adequate supplier. According to the build-to-order process framework (Gunasekaran and Ngai, 2005), this has to be

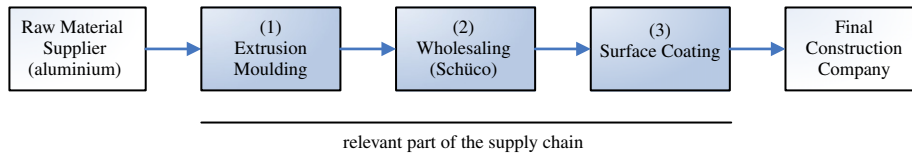


Fig. 3. Supply chain of the façade components manufacturer.

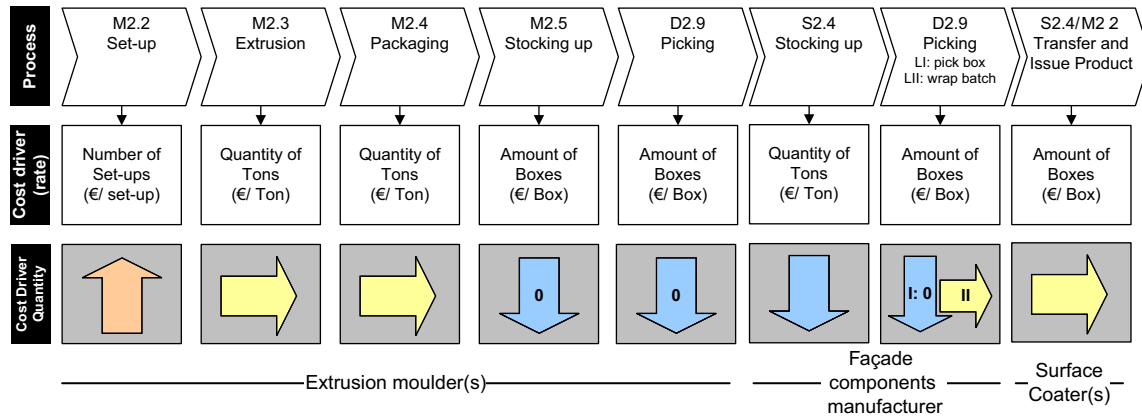


Fig. 4. Supply chain of the façade components manufacturer.

in accordance with market demands and production process specifications. The delivery time was chosen as the main service level attribute, whereas a minimum extrusion capacity for each production run was given for technical reasons.

The case company mapped its own processes as well as the standard production processes of its suppliers. For each process element, a standard cost driver was defined. For spatial reasons, only the main elements of the order-to-delivery process are presented in Fig. 4 as well as the corresponding cost drivers.

Based on the cost driver definitions, the consequences of the build-to-order strategy on the cost driver quantities were estimated together with some of the façade components manufacturer's long-term suppliers. It revealed that quantities for stock keeping of the profiles as well as for order picking would decrease to a zero amount, as warehousing processes would not be needed anymore. However, it also revealed that the cost driver quantity for machine set-up and the supporting processes would quintuple per profile when turning from weekly based production to an extrusion process on a daily basis (economies of scale effects). The forecasted variation in the various cost driver quantities brought up two significant questions. First, it had to be evaluated whether the increase in set-up cost driver quantities could be offset by the estimated decrease in the warehousing cost drivers for any supplier in question. If not, how could this increase in supplier cost be balanced with the gains achieved by the façade components manufacturer? Second, in logical conclusion to the first question, it had to be evaluated which factors form the main impact on the cost-driver rate for set-up. Thus, in contrast to determining the activity-based set-up costs of all suppliers, the case company decided to select a supplier, which performed well in these areas. This supplier was selected as it served as a representative, well performing supplier. Thus, a supplier was selected on the basis of how he performed in terms of set-up time for the change of the extrusion tool, the time for refurbishing the extrusion tool (as determining the amount of necessary tools per article), the initial scrap rate for each batch and the extrusion quantity as well. Based on a survey of respective suppliers, two suppliers were selected and chosen for a deeper quantification of the activity-based process costs.

On the other hand, the façade companies' products were subject to an activity-based process analysis as well. Depending on the kind of profile, cost driver quantities varied significantly, leading to imbalances along the supply chain. As mentioned, in the BTO-SCM strategy, products had to be produced on a daily basis to hold service levels, in contrast to the weekly production batches. Therefore, although being above the technical minimum quantity, cost driver quantities indicated that total volume was still too low, as reductions in the cost driver quantities of the warehousing process would be offset by the additional set-ups. As a result, the pre-selected 200 products were reduced to 75 articles.

5.3. Product design in the supply chain

Activities in this field concentrated on efficiency increases concerning the offered product spectrum. A façade component consists out of two profiles (one inside and one outside), which are put together by a polymer bar, which in total determine the thermal insulation and the total width. However, the aluminium profiles of the same insulation type are produced in different width to get the total needed width necessary for construction as the polymer bar has a standard width.

In the following it was economically evaluated how changes in product design would affect total supply chain costs. Thus, in contrast, to produce aluminium profiles in different widths, it was simulated to use different polymer bars and only one standard aluminium profile per insulation type. Assuming that there exist 20 different insulation types with 30 profiles each (15 inside and 15 outside shells), thus in total 600 profiles, using two different types of polymer bars, 225 different widths can be produced by combining one of those 15 shells with one of those 15 outside shells. Producing only one type of aluminium profile would mean a reduction in production spectrum of 94% to just 40 articles, respectively. However, in order to be able to produce the same range of widths, the number of polymer bars had to be increased up to 450. Summing up, the total product spectrum of polymer bars and aluminium profiles would be reduced to 490 articles by 18%, respectively.

It was evaluated that this reduction would have enormous effects on the cost driver quantities as the cost driver quantity for the set-up process would be halved in BTO-strategy. Moreover, sales volume per article would increase by aggregating the demand of two different profiles up to one. Thus having to disclose articles from BTO-strategy for the reason of low production volumes, some of these articles would be suitable yet having integrated two product variants into one from a technical point of view without infecting customers' options. Moreover cost drivers quantities, as e.g. the number of order positions, would be halved, too, and also necessary picks in the order picking process would also be significantly reduced.

5.4. Formation of the production network

Whereas in the first phase of configuration the suppliers and articles for the build-to-order process design were selected, the second phase dealt with how to calculate and distribute the potential benefits in order to reallocate the specific production functions. Being confronted with the complexity of inter-business cost accounting and, in addition, with varying cost driver quantities due to process redesign, the time-driven activity-based costing methodology formed a suitable tool. The cost-driver rates were calculated accordingly.

As a result, the supplier's savings, i.e. elimination of warehousing activities, were offset by the mentioned 250% increase in cost driver quantity for the extrusion set-up process. However, the calculation of cost driver rates revealed the following: the costs for the order picking process at the focal company (D2.9) were mainly influenced by (1) picking a complete box from the shelf and transporting it, (a) to a wrapping location or (b) directly to the shipping location, and (2) wrapping batches. The later process is carried out by picking a defined number of profiles out of a complete box and wrapping customer-specific batches for each article. After extrusion (M2.3), the profiles are transported with a conveyor belt to a location, where they are put into the standard boxes. Thus, the cost driver rates could be reduced by 30% by locating the wrapping process directly after the production run and handing the complete wrapping process over to the supplier.

Large customers of the case company often buy complete boxes. Calculating the cost driver rates for the surface coating companies (S2.4/M2.2), a significant amount of time was spent to open the boxes, pick the profiles out of the boxes and to dispose of the corrugated paper. However, having eliminated many of the handling processes, covering the profiles was not necessary at all anymore and would only form a logistical function. The calculation of cost driver rates for packing the profiles into boxes at the supplier's site (D2.4) revealed that these were nearly the same as for packing the profiles directly into a pallet for transport, as the activities were the same. Thus, by packing the profiles into the transport pallets, the cost driver rates of the surface coating companies could be reduced as well by 16%. A positive side effect of both examples was that the material costs for the corrugated paper boxes were reduced to zero as well as the costs for disposing of these boxes.

5.5. Process optimisation in the supply chain

Aiming to increase the efficiency of the various processes, the effect of mechanical process atomisation was simulated as well. Here, one example is described. Instead of packing the profiles in the pallets by hand, the activity-time for packaging one ton of aluminium could be reduced by about 20% when using a packaging robot. Besides decreasing the activity time, activity costs could also be reduced. After implementation, the department's total expenses would consist mainly of costs for amortisation and

maintenance for the robot, which were much cheaper than the actual staff costs. Thus by lowering cost centre related costs and respective activity time, the model revealed a reduction potential of 75% for the cost driver rate and the process costs, respectively.

Summing up, by using the activity-based costing model, the advantages of a build-to-order strategy could be assessed. Two significant potentials were revealed. First of all, total supply chain order processing costs could be reduced significantly by about 50% for the chosen profiles. Due to the effect that all members of the supply chain participated in the cost reductions, possible shortcomings of one member were not to be balanced by the gains achieved by another. Besides cost reduction, customer service could be enhanced. As profiles were build-to-order, former out-of-stock situations were not possible by definition resulting in a 100% customer order availability.

If cost reductions would have only been achieved at one company along the supply chain the question of reward sharing would arise (Hennet and Mahjoub, 2010). In such a case, the accounting data should be used for evaluating the specific situation, so that the related contracts might be amended accordingly (Israelsen and Jørgensen, 2011). It might be dependent on the supplier-buyer relationship on how such cost sharings would be distributed. Yet, given the fact that the suppliers are of strategic relevance, sharing cost savings should be of mutual interest.

6. Discussion

Within this paper we developed an activity-based costing model for supply chain management and provided evidence from a single case study as a first related empirical contribution. This addressed the two research questions given in the introduction.

Taking this approach to empirical research, it was possible to get deep and detailed insights into the problems of inter-firm cost accounting of a 3-tier supply chain. Data collection spans across the related companies, thereby fulfilling a requirement of "real" supply chain management related research (Hilmola et al., 2005; Seuring, 2008). Such empirical supply chain research on the whole supply chain is still rare. This is not a contribution in itself, of course.

On the theoretical side and therefore addressing research question 1, previous research on cost issues in supply chain management (LaLonde and Pohlen, 1996) and in particular activity-based costing (e.g. Seuring, 2002a; Möller and Möller, 2002) is extended. The activity-based costing framework for supply chain management outlines the single steps that are required to be taken for such a supply chain wide cost approach. This is not the case in any of the related publications reviewed and discussed in the literature review. It might be straightforward that activity-based costing is applicable in supply chain environments. Yet, this has only been done in a limited manner so far.

Dealing with considerations regarding an effective network set-up and spreading of production activities as well as with efficiency increases, it covers the configuration phase of supply chain management as well as the operation phase, which often includes effort of interface optimisation among supply chain partners. The presented model is able to integrate all aspects covered in previous frameworks and offers opportunities in applying activity-based costing to an inter-company context. Hence, the framework provided in Fig. 2 extends previous research both towards the aspects of supply chain management covered as well as the process of applying activity-based costing across companies.

The second research question is addressed by presenting evidence from a single case study. Within the case study, this is combined with issues of the strategic design of a supply chain, where a move to a build-to-order mode is taken (Gunasekaran

and Ngai, 2005) to improve network effectiveness. The use of standardized cost information is required. If such information can be obtained and if the companies in the supply chain are willing to exchange it, this might allow improving the cost structure of the supply chain. This requires that companies would be willing to open their books (Mouritsen et al., 2001), which is a very critical issue. Here the model's inherent data collection and analysis process helped to collect data from informants in different companies, which allowed triangulation and therefore improve validity. In line with this, we are aware that we report a positive case, where companies acted in line with each other. Yet, supply chains are inherently based on the competitive positioning of each single company. This might lead to rivalry and competition among companies, which triggers opportunistic behaviour in supplier–buyer relationships (Israelsen and Jørgensen, 2011). In this respect trust among business partners becomes a prerequisite before open book accounting measures would be put into practice.

Overall, a single case is a major limitation in itself. Hence, we can only argue for analytic generalisation of the framework. Yet, for the purposes of validating the framework, a case study based on a wide range of empirical data offers a first exploratory approach. By carefully documenting all steps of the research process, reliability and validity were aimed for. Time, cost and access to companies are important constraints, which make it a major challenge even when researching a limited number of related cases. One clear route for further research would be to identify more similar supply chains, so that a multi-case research design could be conducted.

7. Conclusion

Although costing issues form a major part of any supply chain project and, furthermore, form a key dimension of supply chain management, only a few research papers propose methods on how to deal with, calculate and distribute costs in inter-firm relationships. This paper revealed that actual approaches focus only on certain aspects of supply chain management, and do not entirely reflect key requirements. Furthermore, practical applications are missing, especially as most contributions, if at all, focus on dyadic relationships. Reasons are the complexity of data standardisation, collection, and processing as well as the inherent complexity of the activity-based costing approach itself. Against this background, a conceptual activity-based costing model was developed dealing with the mentioned criteria.

The model was tested in a case study. The case study revealed that standardized cost information, i.e. an activity-based costing tool implemented at all supply chain members, can support related supply chain decisions. Through standardisation of cost information activities, processes can be assessed regarding an effective overall design and an efficient performance. Moreover, in the case of shifting activities in order to improve overall supply chain performance for the sake of increasing one member's costs, overall benefits can be distributed equally across the members of the supply chain. However, the supply chain under consideration is characterised by long-term partnerships. The focal company can foster directions and changes easier than in heterarchical supply networks. Another point is that the case study focussed on production and distribution issues, although cost aspects of e.g. product development in supply chains should also be investigated to validate the model.

Summing up, the model and case revealed that inter-company cost accounting along the supply chain can foster strategic decisions. However, there is still need for research identifying origin, scope and classification of cost factors exogenous to a company's own sphere of influence. Thus it has to be evaluated in detail what sort of company-specific decisions affect the cost

situations of suppliers and customers and how these decisions can be communicated along the supply chain, respectively, before they are made. Against this background, supply chain integration needs to be discussed with some kind of neutral distance. In fact, only certain processes should be integrated under the premise of a better total supply chain performance. Aiming at integrating all processes may work against this objective.

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