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Extending the Supply Chain Operations Reference Model: Potentials and their Tool Support

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EXTENDING THE SUPPLY CHAIN OPERATIONS REFERENCE MODEL: POTENTIALS AND THEIR TOOL SUPPORT

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Abstract

The SCOR-Model is one of the most applied reference models to support the description of supply chains. It owes its wide dissemination particularly the activities of the Supply chain council with its close to 1.000 members from practice and research. The paper investigates potentials for future extensions of the model. On the basis of an explorative survey of 20 professionals a framework for extension potentials of the SCOR-Model was developed. By an exhaustive analysis of 53 case studies this framework was affirmed. The framework is used to analyse requirements on modelling tools to support the application of a respective extended SCOR-Model. A concept of a tool support which accomplishes most of the requirements is described and realised as a prototype which is introduced in this paper. With the presented tool concept the basis for a progressive extension strategy for the SCOR-Model is provided which opens new perspectives for the Supply chain council.

Keywords: Supply Chain Operations Reference Model, Supply Chain Management, Reference Modelling, Configuration.

1 DEVELOPMENT STRATEGIES FOR THE SCOR MODEL

The SCOR model (Supply-Chain Council 2006) is a reference model developed by the Supply-Chain Council (SCC) for the design of the value adding chain between two or more companies. Its development was started by the initial 10 members of the SCC in 1996. The first version of the model was published in 1998. Today, the SCC has close to 1.000 members and the most current release of the SCOR model is version 8.0. The SCOR model is one of few reference models designed for supply chain management and – apart from software reference models – due to its recognition among practitioners one of the most used ones in general, independent of a domain specific context. Because of this it would be advantageous to address the further development of the SCOR model. For further information about the SCOR model see Supply-Chain Council 2006c.

The starting point of this paper is that extensions (in the meaning of added functionality) to the SCOR model would make it unmanageable, decreasing the motivation of companies to adopt it. This has already been mentioned by different sources and also by the SCC themselves (Huang et al. 2005, Poluha 2005, Supply-Chain Council 2006a). This defensive strategy for the further development by the SCC brings about the following two areas of discussion.

The first area discusses the question that the development of the model is already that advanced, such that its users do not have the need for any further extensions. This in turn would make further developments unnecessary.

If it is possible to identify enhancement potentials regarding the SCOR model, this leads to the second area of discussion which addresses the question whether all or just specific extensions need to be discarded, due to the fact that this would increase difficulties for the users and designers in the handling of the SCOR model. If it is found that advanced modelling techniques exist that can be used to extend the SCOR model, they will need to be conceptualized and prototypically implemented. In turn, this would contribute to the support of a more progressive development strategy of the SCC.

Our research to the two areas has been initiated with the assumption, that approaches of the software based configurative reference modelling (Delfmann et al. 2006, Knackstedt et al. 2005, Rosemann et al. 2005, Becker et al. 2004, vom Brocke 2007) are an useful contribution to the handling of an extended SCOR model. The goal is to develop relevant extensions which are then supported by adequate software based modelling tools. This artefact is a contribution to solve problems in the area of Supply Chain Management and the management of the model itself. Therefore, the research project can be characterized as design science approach. The guidelines developed by Hevner et al. (2004) build a foundation of the research project (see table 1).

	Justification of this research project	Findings presented in this paper and further research requirements
1. Design as an artefact	The artefact that has to be created in the focus of our research project is an extended SCOR model, from which application specific variants can be derived by configuration with the support of specific software.	The extensions and the supporting software have already been prototypically implemented. In the future, the extensions, as well as the software should be further developed. In particular, the procedure model for the application of the SCOR model needs to be integrated into the project.
2. Problem relevance	An explorative preliminary survey confirms the relevance of particular extensions and the software support. A detailed analysis of case studies reinforces this confirmation.	In the future, the ascertainment of extension requirements should be expanded. The number of analysed case studies should be increased and the preliminary survey should be repeated with a larger number of participants.
3. Design evaluation	In the scope of the prototypical design, the approach of the software supported configuration of an enhanced SCOR model was evaluated. This demonstrated its workability.	The implementation of the prototype should be pushed ahead (see guideline 1). Furthermore, the extended SCOR model should prove its usability in day-to-day business. It should also be examined by theoretical and practical SCOR model experts.

4. Research contribution	As a reference model, the SCOR model serves as an instrument for the explication of economical knowledge of best and common practices. The extensions developed during this project improve the SCOR model to a degree, where it is able to provide more economical knowledge than it does now. Furthermore, the project uses the concepts of configurative reference modelling with an established reference model. Through the ability to create variants and the development of the extensions, it is possible to increase the usability of the model in day-to-day business.	There is actually little scientific research regarding the SCOR model and its usage. Most of the articles only deal with the reproduction of the reference model's structure or suggest its usability in the context of Supply Chain Management. This paper systematically identifies extension potentials of the current SCOR model and presents a software based approach that helps to deal with complications associated with the extended model.
5. Research rigour	The extension potentials of the SCOR model are identified through empirical research and our own critical reflection. Furthermore, existing scientific literature was analysed. The extensions were developed by referencing to literature and day-to-day business. The supporting software was developed in accordance to the concepts of the configurative reference modelling. The evaluation of the approach will be done through its prototypical implementation and its application in day-to-day business, based on case study scenarios.	Firstly, this article focusses on the identification of extension potentials of the SCOR model. Secondly, it incorporates the concept of configurative reference modelling to enable the use of a software tool to handle the extensions. Finally it presents a prototypical evaluation of the approach.
6. Design as a search process	The project can be characterized as a search process due to many factors. Firstly, not all extension potentials can be realised simultaneously. Secondly, it is possible, that concepts for existing extensions have to be reworked in order to add new extensions. Thirdly, due to the ongoing evaluation of the developed artefacts (model, modelling technique and software, see guideline 3), it is possible that they will have to be altered as well.	The research of this article can be characterized as a search process especially because of its multi-level composition. An explorative, preliminary survey was conducted, which already showed particular extension potentials and existing approaches of software support. On top of this, a reference framework was developed and subsequently supplemented by the results of the detailed analysis of case studies. The existing approaches of software support were substantiated by theoretical modelling literature. The software was analysed whether it is able to handle the proposed extensions to the SCOR model. The resulting concept was evaluated with the use of a prototype.
7. Communication of research	The communications of the results include the documentation and the provision of the developed artefacts, as well as the description and recording of the collected empirical data.	The article presents the results of the preliminary survey, the analysis of the case studies for identifying model extension potentials as well as the concept for the supporting software and the realisation of a working prototype.

Tab. 1. The project in the context of the Design Science Research Guidelines by Hevner et al. (2004) as the basis for this article.

Below, the two areas of discussion mentioned above will be introduced. Firstly, the results from an explorative preliminary survey will be presented, which shows extension potentials of the SCOR model and gives ideas on how it can be adequately supported through software (chapter 2). With regards to the first area of discussion, the findings of the explorative preliminary survey provide a basis for a detailed analysis of the case studies (chapter 3). The two succeeding chapters are dedicated to the second area of discussion, namely the usage of advanced modelling tool support for the development of the extensions (chapter 4) and the evaluation of the resulting concept via a prototype (chapter 5). Then the findings presented in this article are compared with previous achievements (chapter 6). Fi-

nally, a summary of the findings of this research will be given as well as an outlook on further steps that have to be taken (chapter 7).

2 EXPLORATIVE PRELIMINARY SURVEY

An explorative survey was conducted to identify the needs for extensions and the effects that the realisation of the extensions might have. For this, structured telephone interviews with European, but mostly German participants were undertaken. The dialog partners with knowledge of the SCOR model were chosen due to their membership with the SCC, from respective entries in their profiles in the former openBC community (http://www.openbc.de, now http://www.xing.de, a community dedicated to the creation of business networks on a friend-of-a-friend basis) or because of personal relations. 6 of the participants were academics, 4 were from the service and consulting industry, 5 were from the electronic industry and 5 of them from the pharmacy/chemistry/medicine industry. The distribution of the participants over different industries shows that this telephone interview has explorative characteristics, such that a representativeness of the sample cannot be assumed.

During the qualitative part of the interview, the participants were openly asked about problems that are associated with the current SCOR model. Often they complained about problems with understanding the model (11 respective comments) and the complexity of its implementation in relation to its use (7 respective comments). On one side it was said that the model is not detailed enough and too general (7 respective comments), while on the other side it was found that the model is too complex (2 respective comments). Additionally, it has to be said that the model's inconsistencies were also stated as further problems (2 respective comments).

Likewise in this qualitative part of the interview, the participants were openly asked about their thoughts regarding the extension potentials of the SCOR model. The most common responses addressed the creation of industry- and/or company type specific variants of the SCOR model, for example a special variant for retail businesses (4 respective comments). 3 participants desired more detailed instructions on how to calculate specific metrics. The general lack of detail in the SCOR model, as mentioned above, is found again in the wishes for a more detailed 3rd level and an expansion to the 4th level (3 respective comments). Furthermore, different extensions with regard to specific business divisions like finance, human resource, customer relationship management or distribution and quality management were proposed. One of the participants recommended the use of a building block like configuration of the SCOR model.

In a further part of the qualitative interview, the participants were openly asked whether or not they thought a reduction in the total model would be meaningful, and if so, in which parts that would be. Predominantly, no recommendations for reductions were provided (16 participants). Potentials in reducing the model were formulated by 2 representatives of the chemical industry regarding the use of the management process *Return*. This, too, is an indicator, that – in this case – industry specific model variants are seen as meaningful. One of the participants remarked that metrics are not necessary and could be removed if the SCOR model is not used for benchmarking. Another participant suggested that some metrics are completely dispensable.

The qualitative interview was concluded with the request that participants provide suggestions for ways in which the SCOR model could be further developed. Important topics that were mentioned were: a desire for extensive operation instructions for the model usage (5 times mentioned); a more detailed explanation of the metrics (4 times mentioned); support given by software products (4 times mentioned), the elimination of redundancies in the model (1 time mentioned); and a stronger usage and integration of formal modelling languages (1 time mentioned).

In the following closed quantitative part of the interview, the participants were asked to judge the relevance of several given approaches to the further development of the SCOR model based on a scale from 1 to 5 in steps of whole numbers, where 1 represents *not at all relevant* and 5 being *extremely relevant*. All of the given developments were ranked *extremely relevant* by at least one participant.

Integration of industry specifics was ranked the highest, followed by the provision of the SCOR model in more languages (see figure 1).

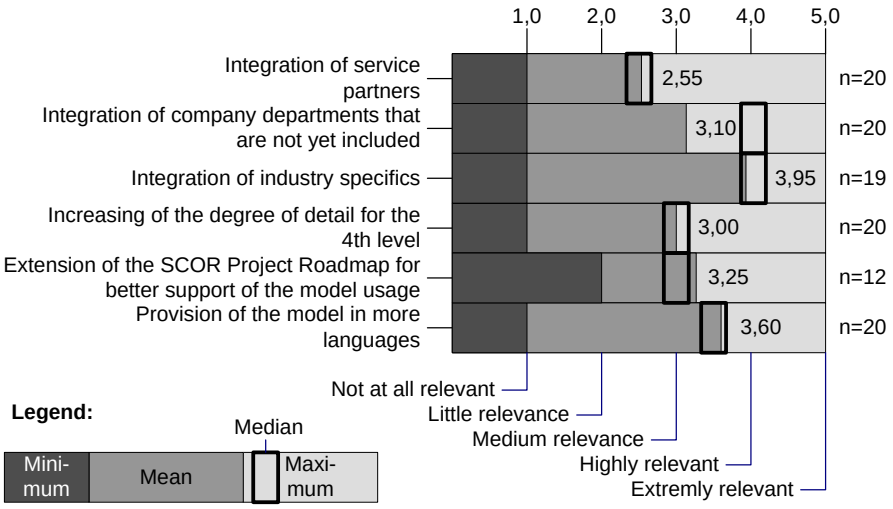

Figure 1. Rating of possible further developments of the SCOR model

The interview was finished by another qualitative part, where the participants were openly asked about their thoughts regarding the impact of the introduction of the respective extensions to the SCOR model. Upon asking whether the complexity of the enhanced SCOR model would still be manageable due to the increased level of detail, 8 participants answered *yes*, 4 answered *no* and one did not have an opinion. One participant explicitly stated that the model would become too complex and the remaining 6 believed, with slight reservations, that the manageability would not be affected. The arguments for these reservations were that – in case of the realisation of the extensions – the possibility of creating variants would be necessary (4 statements), that the application would have to be supported by a software based configuration tool (1 statement) and that the application would have to be intensely taught during workshops (1 statement). Following, the participants were explicitly asked how they judge the offering of different pre-packaged SCOR model variants for an easier handling of the extended model version. 14 participants rated the possibility of creating variants as *good* while three rated them as *bad*. 1 participant explicitly pointed out that the creation of model variants should be used to represent different types of enterprises. After being asked explicitly, all except one participant responded by stating that the usage of supporting software for the creation of variants would be meaningful. Nevertheless, 11 of the participants believe that it would be hard to implement such a software tool and that it could possibly be fault-prone.

As result of the explorative preliminary survey it can be concluded, that a multi-layer spectrum of extension potentials of SCOR model exists and that it seems to be advantageous to use a supporting software tool when realising them. Both aspects will be discussed in further depth in the following chapters, whereas first of all the identified extension potentials will be reinforced by a detailed analysis of the case studies. Afterwards, the benefit of a supporting software tool will be first analysed theoretically and then verified through a prototypical implementation.

3 ANALYSIS OF CASE STUDIES FOR THE IDENTIFICATION OF EXTENTION POTENTIALS OF THE SCOR MODEL

The explorative preliminary study identified a number of extension potentials that were reinforced by the results of the interview. The framework in figure 2 structures and illustrates these potentials. The enhancements, located around the centre of the framework, can be divided into the four categories *Extensions*, *Quality Assurance*, *Tool Support* and *Variants*. Each of these categories combines several

instances identified during either the explorative preliminary study or by the analysis of the case studies.

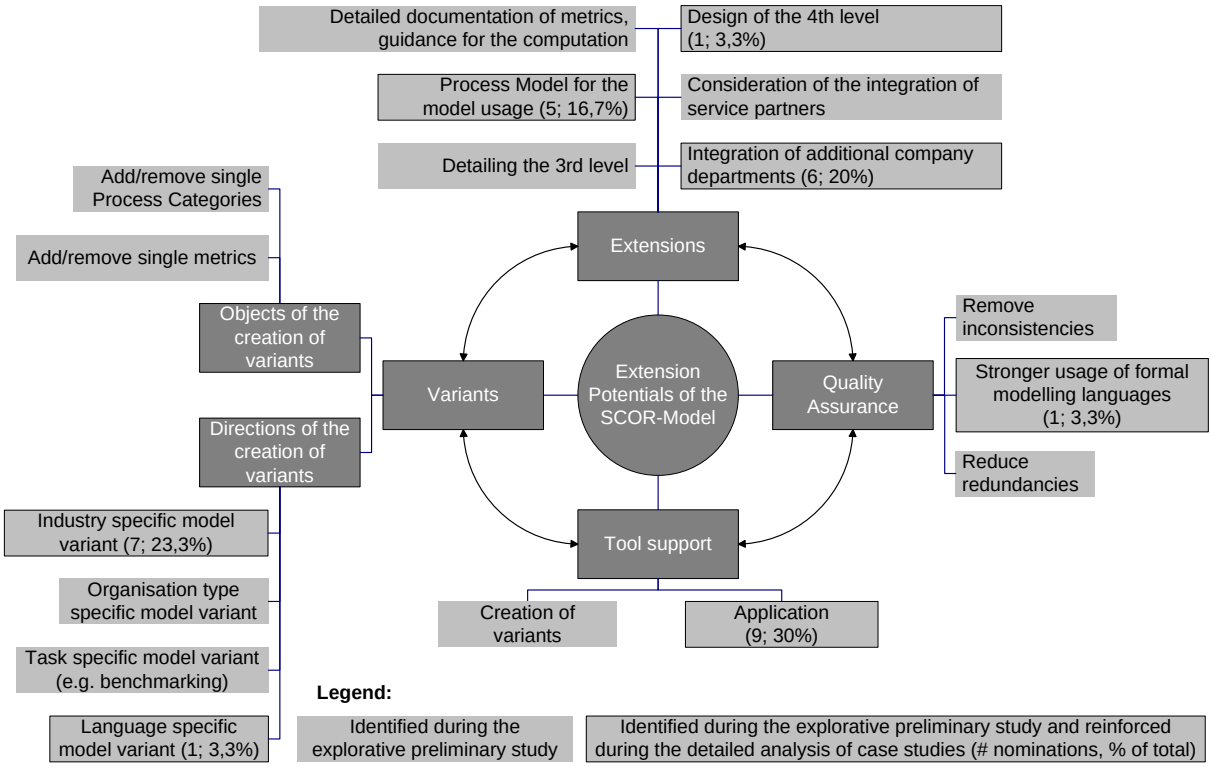

Figure 2. Framework of the identified extension potentials of the SCOR model.

The Supply-Chain Council offers access to case studies that were submitted by its members for presentation purposes in workshops or conferences like the Supply-Chain World America (Supply-Chain Council 2006b). For this reason, the case studies exist as PowerPoint Presentations. Manifested in their charter, members of the SCC are encouraged to support the development of the SCOR model by giving feedback about the way they use the model and the outcomes achieved. Parts of these case studies were carefully examined to extend and approve the preliminary study. All in all, the website of the SCC currently (as of 2006-11-15) provides 163 case studies, submitted by 117 different members. Some of them are solely descriptive – meaning they just describe the SCOR model as it is –, whereas others deal with its application in day-to-day business and the occurring problems and/or suggest improvements as well as ideas of potential extensions.

This analysis is based upon a random sample of 53 case studies as a starting point until now, which were qualitatively examined. In this context, it was evaluated whether the company or research establishment proposed any extension to align the model to their needs, or whether they used existing software solutions supporting the modelling or usage of the SCOR model. Furthermore, mentioned criticisms and problems that aroused were identified.

Figure 3 demonstrates how the case studies can be split up into different industry branches, based upon the North American Industry Classification System (NAICS). Every vendor of a case study was first classified into one of the detailed six-digit categories and then was later on grouped with others into two-digit categories.

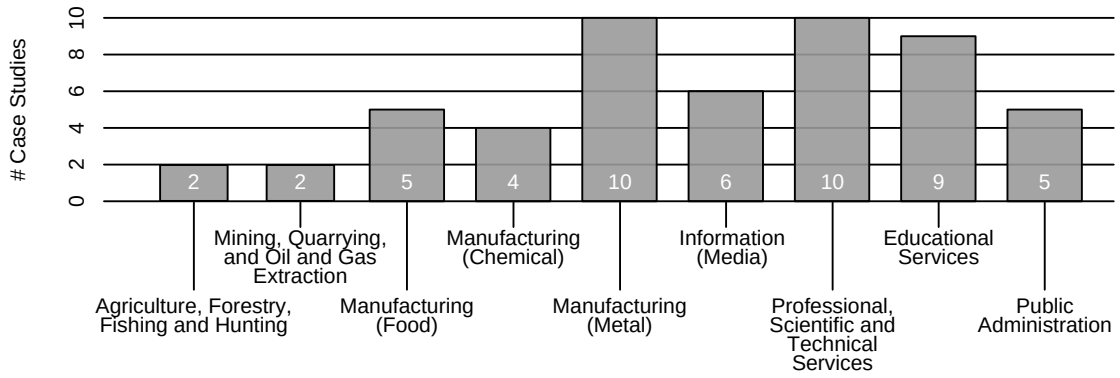

Figure 3. Categorisation of the case studies into industry branches provided by NAICS.

Whereas in a total number of 32 (60%) of the case studies no advice was given on how to improve or extend the SCOR model, in 21 (40%) of them ideas were given. It was possible that multiple extensions or criticisms were formulated in one case study, which led to a total of 30 suggestions for improvement, being categorised in 7 categories, corresponding to the ones identified during the explorative preliminary study. Figure 2 demonstrates the distribution of these suggestions among the different extension potentials previously identified. The following important changes – all of which extend the model – were identified, whereas the total number of statements and the respective percentage rate can be found in figure 2: Firstly, the development of a software tool that supports the application of the model. At most, the existing software solutions only support the design of a supply chain and often the modelling technique *SCOR* is not fully integrated, which compromises its usage. Secondly, the lack of an industry specific adaptation of the SCOR model, including the 3rd level process elements such as the metrics, has been recognized as problematic, especially with regards to the changing of original SCOR metrics to suite the company's individual requirements. Thirdly, the inclusion of additional business divisions and finally the provision of more language specific variants of the SCOR model were encouraged.

4 DEVELOPMENT OF A SOFTWARE SUPPORTING APPROACH

As a result of the previously discussed needs, three areas that can be worked upon were identified. It has to be said, that the request for a process model will not be included in further discussions found in this article but will be still addressed as a general topic with regards to the overall project.

Extensions to the modeling area

Software tools already exist, that enable the modeling of Supply-Chains based on the SCOR model technique. These tools are not capable of fulfilling all the above mentioned requirements (see figure 2), however partial solutions were able to be provided. With increasing the degree of detail in the 3rd level, new elements will have to be added, which should be possible with the current software tools. Because of the implicit integration of a *SCOR meta model*, the application of such tools supports the quality assurance, which addresses the areas of inconsistencies and redundancies. However, due to the limitations of the modeling area, it is not possible to create the 4th level of the SCOR model or add functionalities like formal instructions regarding the computation of specific metrics. In order to incorporate these elements, a different approach is required, which leads to the second area, meta modeling extensions.

Extensions to the meta modeling area

In general, the SCOR model is a hierarchical model consisting of five process types, namely Plan, Source, Make, Deliver and Return, which are refined to the 2nd level through process categories. These categories are used to design the model of a supply chain. Figure 4 illustrates the meta model of the SCOR model – designed by using the extended Entity-Relationship-Model technique (Cheng 1976;

Smith, Smith 1977) – where the process categories and processes types as well as the elementary processes can be identified as process elements, which is illustrated by the usage of the *D,T* element (disjunct, total). The meta model has been developed by the authors by reengineering it due to the information supplied by the reference model itself. The relation *PC-Condition* enforces the fact that the use of certain process categories requires the application of other related process categories, e.g. the application of *Make-to-Stock* requires the usage of *Plan Make* and *Enable Make*. With its connected elementary processes, the 3rd level of the SCOR model outlines the respective superior process categories. It is important to state that every process category has only one corresponding elementary process model, and vice versa. The order of the elementary processes is defined in the *EP-Order* relation. The relationship between the process elements in general and elementary processes in particular are not clearly defined in the SCOR model as it is actually being distributed, such that the relation could either be transporting of an object, transmitting of data or temporal dependencies. Due to this lack of clarity, the *Interchange Object* element was included. It is necessary to point out, that the *Output* of an *Interchange Object* has to be an *Input* for another *Interchange Object* and vice versa.

The meta model shown in figure 4 also includes the *Performance Attribute* element in conjunction with the *Metric* and *Best Practice* elements as well as the additional meta model elements, *Level 4 Process Element*, *L4PE-Order* and *Calculation*, which were brought about as a result of the previously identified needs. Considering that none of the currently available software solutions offer the possibility to manipulate the included meta model of the SCOR technique, the newly designed prototype is required to, so, for example, it needs to be able to construct new types. This leads to the necessity, that the prototype has the functionality of a meta modelling tool, which will enable it to adopt future extension to the SCOR model.

Extensions for the creation of variants

It is also not possible to generate company specific or company type specific variants of the SCOR model within the modelling area. Due to this, the methods of the configurative reference modelling are used (Delfmann et al. 2006, Knackstedt et al. 2005, Rosemann et al. 2005, Becker et al. 2004). To do so, specific elements of the SCOR meta model have to be extended such that configuration terms can be attached. The form of a configuration term as it has to be attached to an element is for example `not(and(industry=automotive;industry=pharmacy))` and when `true`, the respective element will remain in the configured model. Elements without a configuration term will also remain in the configured model. As an example, when the user chooses the parameter `industry=chemistry`, the result of the evaluation of the given term, carried out be the business logic of the prototype, would be `false`, so the element would be removed. The way this actually works will be illustrated in chapter 5.

To realise this in the meta model, the elements which are highlighted in figure 4 have to be extended in order to include a configuration term. To support this, the prototype has to be able to create terms and attach them to their respective elements, which enables to model to be configured. To configure an enabled model, the software has to evaluate the terms and consistently remove the elements that are not required from the model. For example, the removal of the Element *Plan Make* has to include the removal of all depending elements like *Make-to-Order*, *Make-to-Stock* and *Engineer-to-Order* as well as *Enable Make*. Furthermore, each element should have the ability to be translated into multiple languages, which can be realised by attaching an associated term. With these extensions the requirements for specific variants of the SCOR model, as required above, can be fulfilled.

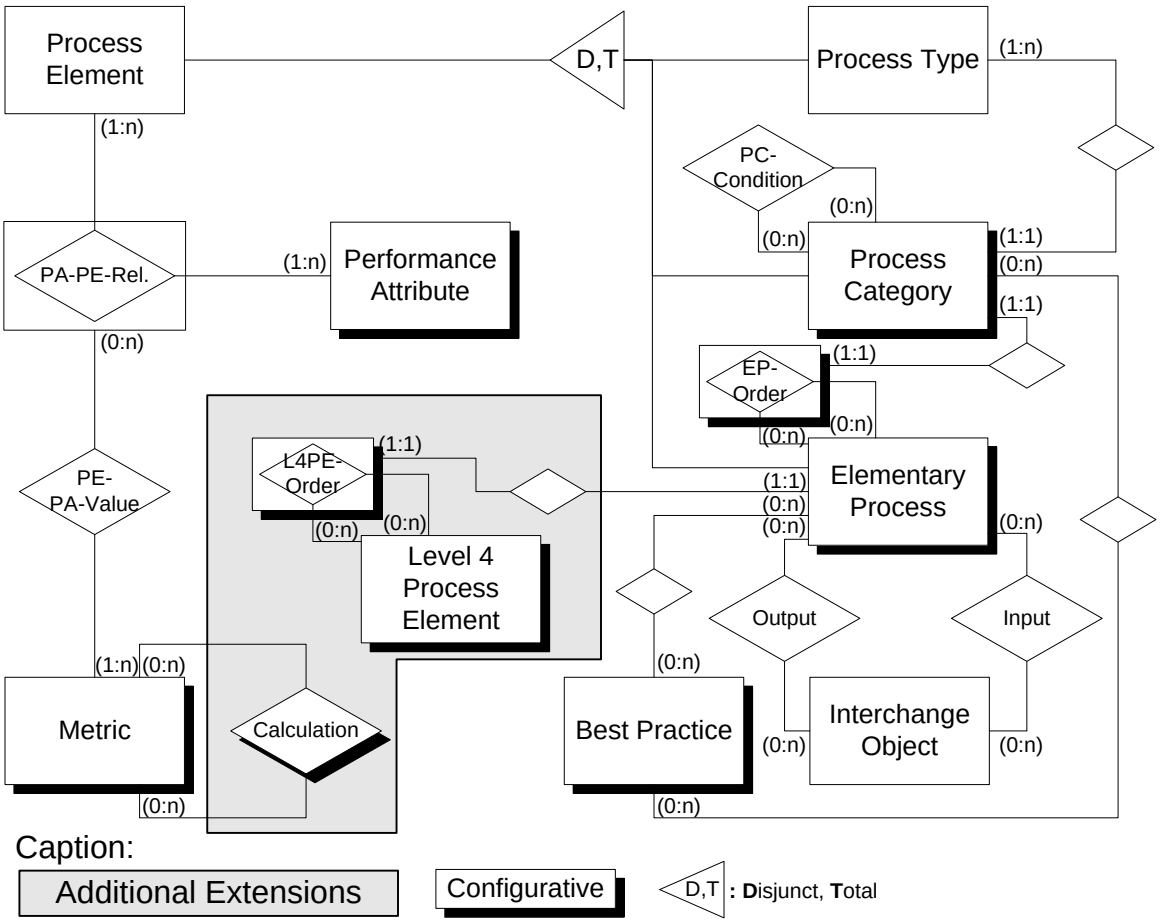

Figure 4. Extended SCOR meta model.

5 PROTOTYPE BASED EVALUATION OF THE SUPPORTING SOFTWARE TOOL

The feasibility of this method was evaluated with a prototypic implementation that was tested with a certain part of the SCOR model. Figure 5 illustrates, which steps have to be taken in order to firstly enable the configuration of the SCOR model and secondly configure it in a language and industry specific way. To enable the configuration, the necessary configuration parameters have to be created (1). Afterwards, they are available in the modelling area, such that the existing elements – in this case the 2nd level process categories – can be extended by them (2). The example shows how the additionally created process category *Make for Automotive* is being provided with the term `industry=automotive`. Every element of the model that has the possibility to be eliminated because it just belongs to a specific perspective has to be provided with an according term. This needs to be done firstly for the current model and then again for any additional element. Once the reference model is configurable, it can be adjusted to suite the specific target group. To do so, the user selects the desired parameters (3) and the resulting model variant is created (4). As seen in figure 5, the user selects the parameters *Automotive* and *Deutsch*, which provides a model variant in German consisting only of automotive industry specific elements. In the background, unnecessary elements of the 3rd level, as well as associated metrics and best practices have been consistently eliminated. By selecting multiple parameters, variants including more than one industry specific elements can be produced.

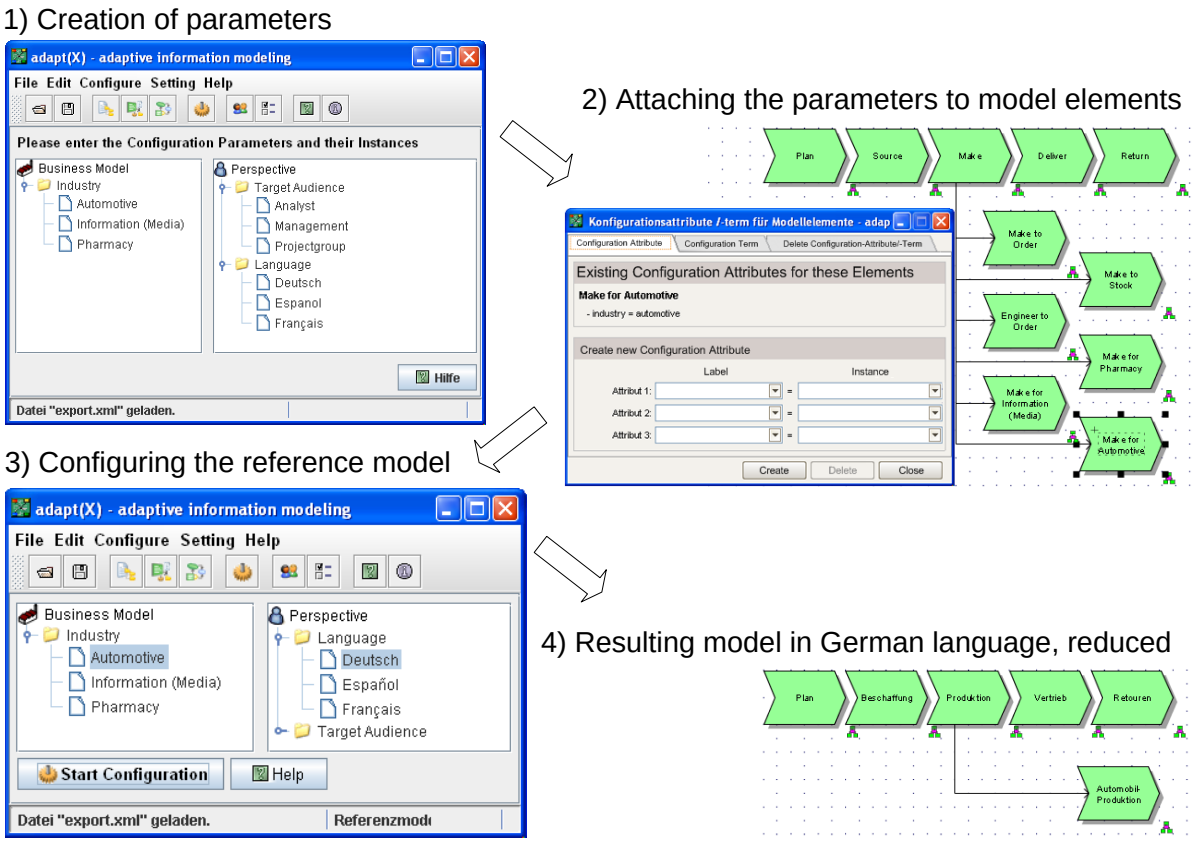

Figure 5. Process Sequence: Screenshots of the configuration tool.

6 RELATED WORK

Current research on the SCOR model mostly takes place in the context of day-to-day business and is carried out mainly by members of the SCC. The scientific debate regarding the model has only just commenced. When mentioned in scientific literature, it only seems to address its structure and/or its meaningful areas of application. Most of the time, the information found in these articles or books are similar, due to the fact that the information is originally obtained by the SCC. To demonstrate the minimal distribution of scientific discussion regarding the SCOR model, the proceedings of the AMCIS and ECIS conferences over the last seven years were analysed. Tab. 2 illustrates the distribution of the articles per year, with *(1/2)* meaning that one article was identified that addressed extensions to the SCOR model, whereas two only described it. Articles that address extension potentials are then described in italics. As all of the articles origin in the proceedings of the respective conference, no further detail is given about them.

American Conference on Information Systems (AMCIS)	2002 (1/0)	Scheer, C. and Theling, T. and Loos, P. (2002). Information Interface Classification of Actors in Supply Chain. – *Extending the SCOR model with information about data exchange*
	2005 (0/1)	Zhang, Tanniru (2005).
	2006 (1/2)	(Kaulgud, V. S. and Kulkarni, P. and Deshmukh, N.: Role of Peer-to-Peer Technology in Enhancing Supply Chain Performance Metrics – *Using P2P Technology with the SCOR* model) / (Caldelas-Lopez et al. 2006, Møller 2006)

European Conference on Information Systems (ECIS)	2000-2002 (0/4)	Peristeras, Tarabanis (2000), Tarabanis et al. (2001), Lejmi (2002) and Meixell et al. (2002).
	2003 (1/0)	Holten, R. and Dreiling, A.: Provision of Customer Knowledge to Supply Chains – *Motivating the extension of the SCOR model by a framework to link internal and external business processes*
	2004-2006 (3/0)	Klose et al. (2004), Krauth et al. (2005) and Henningsson, Carlsson (2006).

Table 2. Scientific research concerning the SCOR model found in the AMCIS 2000–2006 and ECIS 2000–2006 proceedings.

As mentioned and seen above, very little scientific research concerning the SCOR model exists. However, two of these few publications that have considerable significance are the works of Poluha (2005) and Hieber et al. (2002). Poluha statistically evaluated metric based data of approximately 170 companies to see whether or not they support the way the SCOR model uses the metrics. The results were predominantly of a positive nature. However, three suggestions for the further development of the SCOR model were given, all three concerning the above discussed *modelling area*. These suggestions are the integration of marketing and distribution, a more detailed documentation of information and material flows between customers and suppliers and finally the inclusion of e-business concepts. Of these, some are obsolete as they refer to an older version of the SCOR model (v. 6.0). However, due to a different focus, the work of Poluha does not provide any extension potentials regarding the previously introduced areas of *meta modelling* and *creation of variants*.

In addition to our prototype other commercial software tools exist that support the application of the SCOR model. For example some of these tools are e-SCOR by Gensym, ARIS EasySCOR by IDS Scheer AG and ADOLog by BOC. These tools support the modelling of supply chains with the process elements provided by the SCOR model. The strength of E-SCOR is, for example, the simulation of the development of metrics for different design alternatives of a supply chain. This is achieved by mapping the original data of the company to the SCOR metrics. ARIS EasySCOR also supports this simulation as well as providing features for benchmarking and process design. ADOLog supports the application of the SCOR model in four steps, spanning from the positioning of the important locations on maps to the designing of 4^{th} level models. All in all it can be said that the three previously mentioned tools simplify the process of modelling project specific SCOR models. Once again, only the *modelling area* is addressed. All of these commercial software products are neither powerful meta modelling tools, nor do they support the creation of any application specific variants. Because of this, they are unable to support the extensions discussed in this article. This is the most considerable difference concerning the presented prototype.

7 OUTLOOK

Based on an exhaustive research – including interviews and case study analyses – this article describes existing needs and the relevance of enhancements to the SCOR model as well as giving a prototype for a supporting software tool. The usability was proven by its application within a section of the SCOR model but has to be proven to be relevant and useful for day-to-day business. The prototype should be completed in at least two years, offering the ability to handle the complexity associated with extensions to the model. We propose that the SCC should begin to look at changing their defensive development strategy of the SCOR model into a more progressive way and simultaneously think about potential extension that they would like to integrate. In our opinion, the necessity of this should be reinforced from us by the analysis of all accessible case studies and a further explorative study with a greater number of participants.

8 ACKNOWLEDGEMENTS

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