INVESTIGATING THE RELEVANCE OF SUPPLY CHAIN IMPROVEMENT SYSTEMS (SCIS)

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Abstract Due to the pressure of competition, high process efficiency has become a corporate objective for companies to maintain their global competitiveness. To ensure high process efficiency, it is important to constantly reduce process losses within various business activities. Different concepts to evaluate the efficiency of a company's key processes have therefore been discussed in academia. These concepts largely concentrate on the production area of one single company. Currently, however, not only individual companies but also entire supply chains are competing with each other. For this reason, it is necessary to thoroughly evaluate and increase the efficiency of production, transport, handling, and warehousing processes along the entire Supply Chain. We addressed this challenge with the conceptual design of a supply chain improvement system (SCIS). The results of empirical research focussing on the managerial purpose of the SCIS indicate that intercompany efficiency evaluation and improvement are prevalent issues in entrepreneurial practice.

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1. INTRODUCTION AND RESEARCH OBJECTIVE

Considering the increasingly dynamic and highly competitive economic environment, focussing on the improvement of internal business activities has proven to be insufficient in maintaining a company's competitiveness in recent years (Lambert, Cooper & Pagh, 1998). For this reason, decision-makers often regard supply chain management as an appropriate management concept in order to substitute intercompany improvements for the companywide perspective (Hahn, 2002). Supply chain management aims to achieve purposeful planning, managing, and control of value-added and non-value-added processes along the supply chain from suppliers to producers and retailers (Winkler & Kaluza, 2006) and (Winkler, 2011).

However, the concept of supply chain management lacks a comprehensive efficiency evaluation of intercompany business processes. We consider the evaluation of the overall efficiency of intercompany business processes inevitable to improve the supply chain performance. Latent process losses are more likely to be detected and reduced when the process efficiency is determined by the use of sophisticated efficiency indicators. Thus, it is necessary to identify an appropriate method that contributes towards filling this gap (Wildemann, 2001) and (Schulte, 2009).

In this paper, therefore, we present an advanced instrument that we call the "supply chain improvement system" (SCIS), which aims to evaluate and improve the process efficiency along the entire supply chain. In doing so, we distinguish between primary and subordinate supply chain processes in the fields of production, transport, handling, and warehousing. Each business activity is the result of a certain combination of such specific processes (Engblom, Solakivi, Töyli & Ojala, 2012).

To begin, we give a brief conceptual description of the fundamentals of supply chain management and identify its current deficits in detail, especially in terms of the efficiency evaluation of supply chain processes. Subsequently, we introduce the SCIS as a complement to traditional supply chain management. A discussion of the relevance of the SCIS for industrial companies based on the results of empirical research follows. In the course of this, we present the applied methodology and give an overview of selected results. Finally, the conceptual design of the SCIS is described in detail.

2. FUNDAMENTALS OF SUPPLY CHAIN IMPROVEMENT SYSTEMS (SCIS)

The conceptual basis for the SCIS is the supply chain management approach, which emerged in the early 1980s and has been further developed since (Cooper, Lambert & Pagh, 1997). Supply chain management supports the integrated strategic and operational planning, managing, and control of the intercompany flow of material, information, and cash from the raw-material supplier to the end customer (Winkler, 2005), (Winkler & Kaluza, 2007), (Winkler, 2011), (Schreckenbach & Zeier, 2003), (Cooper & Ellram, 1993) and (Cox, 1997). All partners along the supply chain aim to generate added value when converting raw or semi-finished products into finished goods according to the customers' demands. In doing so, non-value-added time, which is considered to be a process loss, must be diminished as much as possible to keep the total and per-unit costs low (Seebacher & Winkler, 2013). In addition to contributing towards delivery of a sufficient amount of products at the right time and of the necessary quality, supply chain management also supports the reduction of cycle times and inventory as well as the increase of productivity (Chin, Hamid, Rasli & Baharun, 2012). Cooper et al. (1997) indicate that supply chain management consists of three major elements. These include the business processes that produce a specific output, the management components that manage and structure these business processes, and the supply chain structure itself, i.e., the arrangement of companies within the company network (Lambert & Cooper, 2000).

However, recent findings indicate that the practical application of supply chain management is not in accordance with its scientific understanding. Although enterprises are usually aware of the idea of supply chain management and its benefits, the concept is often not implemented fully, mostly due to security issues. Companies keep a strong focus on internal business processes instead of choosing a holistic approach that constitutes the prerequisite for a successful supply chain. Currently, process data along the supply chain are therefore not transparent enough to provide a solid basis for joint planning and forecasting activities. Seamless and honest communication and data exchange between supply chain partners is imperative to counter a disrupted flow in valuable information (Winkler, 2005).

Simultaneously, objective assessment of bottlenecks and sources of process loss along the supply chain is often neglected due to the lack of methods to evaluate the efficiency of relevant business processes along the supply chain. Scientific literature currently discusses several approaches to the evaluation of the efficiency of business processes (Muchiri & Pintelon, 2008), (Braglia, Frosolini & Zammori, 2009), (Oechsner, Pfeffer, Pfitzner, Binder, Müller & Vonderstrass, 2002), (Nachiappan & Anantharaman, 2006) and (Sheu, 2006).

However, methods such as the Overall Equipment Efficiency are mostly limited to production processes and aim to separately improve individual business processes (Piser, 2004). Thus, they do not offer a comprehensive evaluation of efficiency along the supply chain. Therefore, specific metrics need to be developed that simultaneously consider the input-output ratios of several business processes (Winkler 2005) and (Sambasivan, Mohamed & Nandan, 2009).

One specific challenge that arises in this context is the difficulty of collecting data related to the logistics process. Even on the enterprise level, appropriate indicators that support the evaluation of logistics processes are scarce even though logistics is prevalent in almost every business process that relates to the movement of goods and information (Engblom, Solakivi, Töyli & Ojala, 2012). Furthermore, the existing evaluation instruments do not take into account the increase in product value along the supply chain. For example, transport damage to a finished good has a greater negative effect on the overall supply chain efficiency than damages to unfinished parts. Additionally, the distinction between technological process loss, inefficiencies in the use of available work force, and the effects on profitability caused by process modifications has yet to be considered.

The identified deficits prompted us to design the SCIS according to the various requirements of the purposeful planning, management, control, evaluation, and improvement of supply chain processes. We developed the main characteristics of the SCIS based on our scientific expertise and practical experience.

In the course of the conceptual design of the SCIS, we modified version 10 of the "supply chain operations reference model" (SCOR model) (In December 2012 version 11 of the SCOR model was released that additionally considers a sixth component „enable".), which is considered to be a schematic image of a typical supply chain. It is divided into the five principal components of supply chain operations: plan, source, make, deliver and return (Stewart, 1997). Fig. 1 shows the traditional SCOR model.

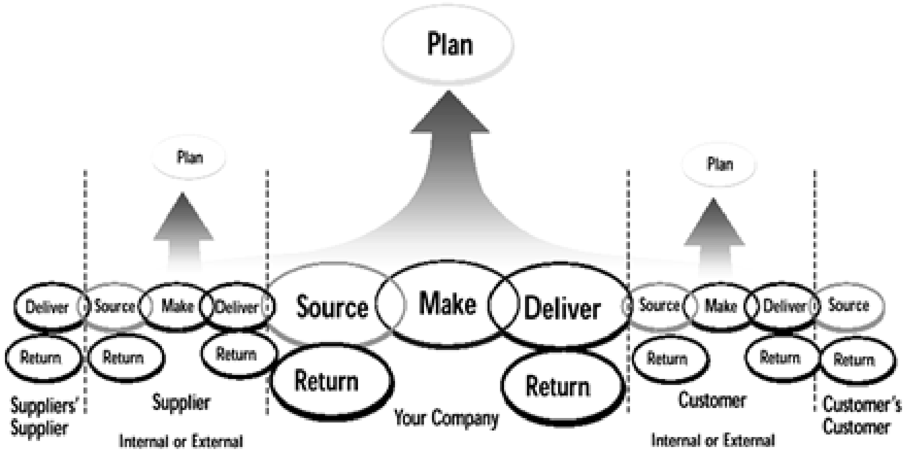

Fig. 1 Version 10 of the supply chain operation reference model

Thus, the SCIS is characterised by a related but slightly unique process structure that includes production, transport, handling, and warehousing processes. Focussing on the reduction of temporal, material, and organisational waste within these specific areas allows for the systematic improvement of the overall supply chain efficiency. In doing so, the SCIS complements the concept of supply chain management by offering the possibility of the objective evaluation of the examined supply chain processes through standardised efficiency indicators.

3. INVESTIGATING SUPPLY CHAIN IMPROVEMENT SYSTEMS

3.1. Preparation and implementation of the survey

The SCIS supports the mechanised and holistic improvement of supply chain processes. Related to this issue, a survey was developed and executed for the following reasons: (1) to assess the relevance of supply chain improvement for industrial companies, (2) to examine the practical requirements of the SCIS, and (3) to define a list of fundamental functionalities of the SCIS. Additionally, the survey was expected to reveal whether the interviewees had already been applying supply chain management or management instruments focussed on supply chain improvement. The survey included structured interviews with nine experts in the fields of production, logistics, supply chain management, and IT. We regard these fields of action appropriate to be surveyed in the context of the SCIS. This is due to the experience in the application and use of operational software systems of the respective employees. The structured interviews lasted 60 to 90 minutes and allowed the interviewees to respond to open questions freely. However, the interviewer was responsible for ensuring strict compliance with the relevant topic (Atteslander, 2010).

After this, an extensive online survey was administered to include a larger sample and to assess the relevance and usability of the previously identified functionalities of the SCIS. Additionally, this format allowed those surveyed to make suggestions of new functionalities that had yet to be considered. Access to the survey was provided via e-mail to approximately 450 persons. Expecting a response rate of 20-25%, the sample size was the result of the objective to receive about 100 completed questionnaires to obtain representative findings. Similar to the previous interviews, the target groups for the survey included experts in the fields of production, logistics, supply chain management, and IT from Germany and Austria. The geographical limitation was linguistically determined. The survey included detailed questions concerning the expected characteristics of the SCIS as well as its practical application and potential for implementation. More specifically, the questionnaire was structured into a description of the basic idea of supply chain improvement and three sets of specific questions. A four-point scale was offered to prevent the tendency to answer questions towards the centre, which is commonly observed in a five-point scale. The first set of questions included general questions related to the potential for improvement along the supply chain. The second set dealt with the conceptual design of the SCIS. The potential impact of the SCIS was examined in the third set of questions. After the questionnaire had been pre-tested and modified, the online survey was administered over a period of four weeks. To increase the response rate, the addressees were contacted after two weeks through a phone call or a second e-mail. The result was a response rate of 20%. Fig. 2 gives an overview of the operation sequence of the survey.

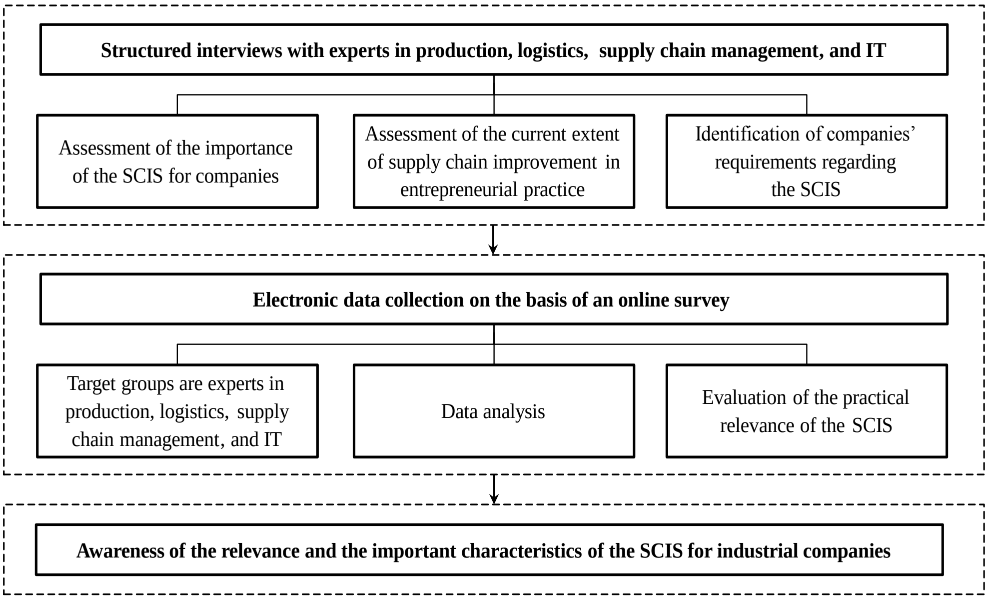

Fig. 2 Operation sequence of the survey

3.2. Selected results of the empirical research

According to the results of the conducted survey, more than 54% of the respondents concluded that the SCIS is "of very high importance" to increase the efficiency of supply chains and exactly 40% of the interviewees considered the SCIS to be highly important for this purpose. Thus, 94% of the interviewed experts believed that the supply chain would become more efficient and thus more competitive with the implementation of the SCIS. Only 5.6% of the total responses indicated that the SCIS is of minor importance to the improvement of the supply chain.

In contrast to this assessment of importance, more than 55% of the respondents stated that measures that correspond to the idea of supply chain improvement are applied to a minor extent or are completely lacking in their entrepreneurial practice. For approximately 37% of those surveyed, the responses indicated that supply chain improvement is currently conducted to a large extent. Less than 8% of those surveyed indicated that concepts to improve the supply chain are already applied to a very large extent. In summary, these responses demonstrate that instruments and methods similar to the SCIS have yet to be utilised on a regular basis.

Thus, one central finding from the survey is that supply chain improvement is neglected by most operational decision-makers even though it is generally considered to be a highly purposeful method. Even traditional supply chain management is not applied in accordance with scientific recommendations. However, most respondents favoured the future application of an appropriate instrument to improve the efficiency of supply chain processes. In addition, the survey revealed the supply chain areas that apply to, and thus would mainly be affected by, supply chain improvement. To discover these areas, the experts surveyed were provided with a list of nine different supply chain areas. The list included fields of action in production and logistics that exist between the supplier, the manufacturer, and the customer. More specifically, the listed supply chain processes included the supplier's production, the supplier's outbound logistics, the transport from the supplier, the own inbound logistics, the own production, the own outbound logistics, the transport to the customer, the customer's inbound logistics, and the customer's production.

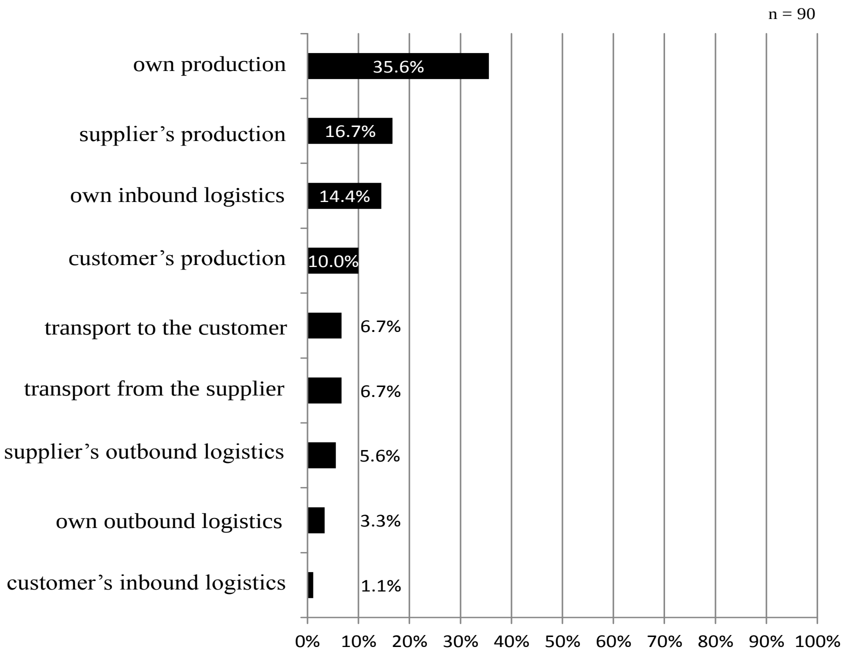

Fig. 3 Assessment of the respective improvement potential along the supply chain

The results indicated that the respondents expect the highest efficiency improvement along the supply chain within the various production processes, with one exception. More than 35% of the surveyed experts viewed the greatest potential for process improvement to be within the own production. This information indicates that even within internal business processes, a lack of data transparency and an excess of non-value-added time exist. Approximately 17% believed that the supplier's production benefits the most from the SCIS. Ten percent of those questioned considered the customer's production to be the supply chain area with the greatest potential for improvement. A similar amount of experts (14%) assumed the highest demand for an increase in efficiency to be in the field of inbound logistics of the own company. Outbound logistics were located at the lower end of this statistical ranking. Only 5.6% respectively 3.3% of the interviewees expected the highest improvement potential in this area. Finally, 1.1% ranked the customer's inbound logistics processes as the area with the highest potential for improvement. Transport processes were located in the middle of this ranking; 6.7% of the respondents see very high potential for improvement in both the transport from the supplier as well as the transport to the customer. In summary, supply chain experts consider intercompany transport processes to be less important than production processes. Nevertheless, they obviously place more emphasis on intercompany transport processes than on external inbound logistics or on outbound logistics in general. Fig. 3 shows the described results in a bar chart.

4. CONCEPTUAL CHARACTERISTICS OF SUPPLY CHAIN IMPROVEMENT SYSTEM (SCIS)

The changing conditions due to a very volatile economic environment that surround the supply chain make it necessary to provide the SCIS with a flexible structure. Furthermore, supply chains tend to have different characteristics when compared globally, and their respective natures are determined by the industry sector. Thus, to meet the requirements of different industrial companies within various external environments, the SCIS can be executed on three independent levels. These three levels guarantee a supply chain improvement that is customised according to these respective requirements. The application of a certain level of improvement often depends on the availability of time, financial resources, managerial requirements, and the provided process data. Especially in terms of logistics processes, data collection along the examined supply chain has proven to be widely neglected until now.

Supply chain improvement at the first level is predominantly project-based and includes the efficiency evaluation of the primary supply chain processes (production, transport, handling, and warehousing). Process status reporting allows the company to maintain a rapid overview of the examined supply chain area. More precisely, a status report reveals the existence of efficiency losses and improvement potential at a glance. Subsequently, the selected supply chain area must be modelled using a specific modelling tool. This is considered to be the basis for further value stream analyses. However, traditional value stream analysis aims to examine only individual production processes. Thus, the method has to be adapted to the particular requirements of supply chain improvement (Arndt, 2008). Moreover, relevant process data must be collected and transformed into efficiency indicators that can be compared to pre-defined planned values. A planned value describes the ideal input-output ratio of a certain supply chain process. Accordingly, the process optimum is achieved if no variance between the actual value and the planned value occurs. A variety of procedural losses, such as unplanned downtime; extended set-up, start-up, and slow-down times; speed losses; defective goods; repairs; increased inventory; and decreased capacity utilisation often exist in entrepreneurial practice (Winkler & Kaluza, 2007). These negatively influence the degree of variance between the actual and the optimum process efficiency. In summary, if financial resources and the available time are scarce, the first level of supply chain improvement is recommended because it delivers prompt results.

The distinctive advancement of supply chain improvement at the second level includes the detailed modelling of all subordinate supply chain processes that together constitute primary processes. This detailed model is considered to be the basis for extensive analyses and significant improvements in efficiency within the selected supply chain area. Additionally, the simulation of various supply chain scenarios is an additional method to detect the potential for an increase in process efficiency (Ben-Zvi, 2012). Thus, improvement in process efficiency at the second level requires sophisticated simulation software, which is offered by specialised IT companies and must be integrated into the SCIS. Simulating modifications within certain supply chain processes (e.g., through "what-if analyses") allows an assessment of the expected results and the respective effect and impact on linked supply chain processes. This prevents decision-makers from taking actions that will have a negative effect on the overall efficiency of the supply chain. The advantage of the second level is the high degree of modelling detail. However, this requires precise and current process data and therefore entails increased expenditure of time and money.

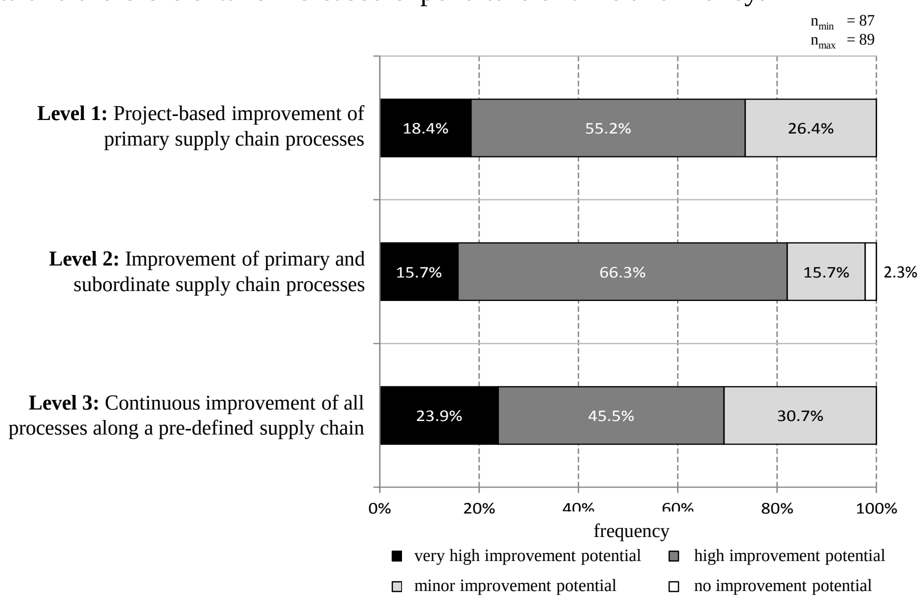

Fig. 4 The potential for supply chain improvement at each level of the SCIS

Supply chain improvement at the third level is characterised by continuous efficiency improvement (Radharamanan, Godoy & Watanabe, 1996). Again, a detailed model of the subordinate supply chain processes is the basis for evaluating and subsequently reducing occurring process losses. To realise a continuous improvement in efficiency, data must be collected and processed in real time from various internal and intercompany IT systems (Winkler & Kaluza, 2007). GPS (global positioning system) and RFID (radio-frequency identification) are technologies that particularly support the data collection of logistics processes (Holström, Främling & Ala-Risku, 2010). Through continuous process monitoring along the supply chain, measures to counter process losses can be applied promptly after the occurrence of a problem. However, improvement at the third level requires a high degree of information accuracy and a wide range of real time data. Therefore, powerful IT systems and appropriate interfaces provide the seamless flow of the large amount of data required. For that reason, data standards have to be defined to ensure their interoperability. Additionally, the SCIS provides visualisation of important information by integrating business intelligence software.

The results of the online survey indicate that a large number of supply chain professionals see improvement potential at each level of the SCIS; nevertheless, 2.3% of the experts expect that there would not be any improvement potential at all with regard to the second level. However, most respondents assume "high improvement potential" irrespective of the supply chain improvement level. Fig. 4 gives a detailed overview of the potential for improvement at each level.

According to the specific and varying requirements of industrial companies, the SCIS offers a wide range of distinctive functionalities that can be categorised into base functionalities and additional functionalities. Base functionalities determine the nature of the SCIS, whereas additional functionalities provide for more extensive and more comprehensive process improvement. Depending on the level of supply chain improvement, the various functionalities have different characteristics, mainly due to differences in detail and the timeliness of the available data. However, not all of the functionalities are offered at each level. Fig. 5 shows the respective functional characteristics at each level of supply chain improvement in detail.

	Functionality	Level 1	Level 2	Level 3
Base Functionalities	Modelling of the flow of information and material along the SC	Modelling of the primary SC-processes (production logistics, transport, handling, warehousing)	Detailed process modelling of subordinate SC-processes with a simulation tool	Detailed process modelling of subordinate SC-processes and interfaces
	Collection of data for the efficiency-calculation of SC-processes	Manually triggered data collection from existing data sources	Manually triggered data collection from existing data sources	Automated data collection from existing IT-Systems / Real-time access to existing data sources
	Processing and analysis of collected data	Manual processing and analysis of collected data	Manual processing and analysis of collected data	Automated processing and analysis of data in real-time
	Calculation of efficiency indicators and presentation with traffic lights logic	Comparison between planned and actual values	Comparison between planned and actual values	Automated comparison between planned and actual values in real-time and classification of the efficiency indicators
	Simulation/ What-if-analysis		Detection of interrelations between individual logistics processes / Assessment of effects of process changes	Detection of interrelations between individual logistics processes / Assessment of effects of process changes
	Notification if necessary/ Reporting in real-time			Efficiency-reports and controlling with a management cockpit
Additional Functionalities	Logistics process costing	Estimation of process costs	Calculation of process costs	Continuous calculation of process costs
	Benchmarking		Intercompany comparison of efficiency indicators over time	Continuous intercompany comparison of efficiency indicators over time
	Tracking & Tracing			Generation of current location information of devices and material through auto-ID-technologies
	Forecast and re-scheduling			Forecasts of external factors that influence transportation processes (e.g. weather or traffic) and re-calculation of delivery dates
	Decision support			Recommendation of solutions to counteract frequently appearing difficulties in logistics processes
	Data export/ Archiving	Transfer of collected data to standard data processing programs	Transfer of collected data to standard data processing programs	Transfer of collected data to standard data processing programs

Fig. 5 Functional characteristics according to the level of supply chain improvement

5. CONCLUSION

For a long time, supply chain management was considered to be an appropriate concept for the improvement of relevant business processes along the supply chain (Winkler, 2005). However, it appears that decision-makers fail to properly operationalise supply chain objectives irrespective of the scientific recommendation. In this paper, we have shown that this is not only due to the ignorance of current methods to evaluate the degree of target achievement along the supply chain but also due to a fundamental lack of suitable evaluation indicators. We consider the use of indicators that facilitate the evaluation of the efficiency of supply chain processes to be the appropriate approach to manage, control, and improve the supply chain. Therefore, we have developed the SCIS, including certain functionalities at three distinctive supply chain improvement levels and sophisticated efficiency indicators in the fields of production, transport, handling, and warehousing. These indicators provide information about the current efficiency status of the examined supply chain processes and thus reveal occurring process losses.

The results of this empirical research indicate the importance of supply chain improvement for entrepreneurial practice. However, measures to achieve improvement in efficiency in supply chain processes have not yet been applied, although they have been largely sought. Further research is necessary to develop methods for the financial evaluation of process modifications (i.e., to demonstrate their overall monetary effect along the supply chain). Agreement upon a standardised monetisation scheme is necessary to comprehensively evaluate process improvements (Ramler & Renner, 2002).

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