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Value of IT in supply chain planning

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Abstract

Purpose – The purpose of this paper is to understand value creation of information technology (IT) in supply chain planning (SCP). The impact of different IT components in SCP remains unclear and requires some thorough research. In addition, an analysis of the optimization dimension provides insights into intra-functional, inter-functional and cross-company optimization.

Design/methodology/approach – A survey was conducted among German companies using a continuous production flow. In total, 47 of 193 contacted companies completed the web survey, which corresponds to a response rate of 24 percent.

Findings – IT functionality for SCP is widely spread. The value of IT functionality in SCP is tremendous. Implementations in demand fulfillment and available-to-promise (ATP) have the biggest value creation potential. Supply chain performance indicators can be improved by investments in certain functional domains. Packaged standard software is widely distributed and should be considered as the first option. IT functionality to improve intra-functional processes is significantly more often implemented than IT functionality for inter-functional or cross-company process optimization although the realized value is comparable.

Research limitations/implications – Respondents of the survey are limited to the German continuous production flow industry. Future research could be interesting in the discrete manufacturing industry.

Originality/value – The paper provides empirical insights into the value of IT in SCP where data are less available than in the ERP context. Furthermore, this paper provides first insights into the optimization dimension whether processes are optimized intra-functional, inter-functional or cross-company.

Keywords Supply chain management, Supply chain planning, IT value, Advanced planning systems

Paper type Research paper

Introduction

Through the effective use of information technology (IT) in supply chain management (SCM), enterprises can develop a competitive advantage (Hassini, 2008). IT can speed up the information flow, thus making the supply chain more robust and resilient without undermining its efficiency (Pereira, 2009). Advanced Planning Systems (APS) complement Enterprise Resource Planning (ERP) systems by providing functionality for elements of supply chain planning (SCP) (Stadtler, 2005). While ERP is already a mature concept and consequently well researched, APS is at an earlier stage.

Global competition has driven companies to the limits of internal operations optimization (such as process control and inventory management) and accordingly there is a need to start integrating suppliers and customers into the overall value chain processes (Prajogo and Olhager, 2012). By enabling the sharing of information with supply chain partners IT can create a real-time integration of the supply chain (Li *et al.*, 2009). Therefore, external logistics information technologies are becoming more and more important compared to internal systems (Savitskie, 2007).

Some research studies have analyzed the value of IT in SCM, but did not address the planning processes comprehensively (e.g. Auramo *et al.*, 2005; Li *et al.*, 2009; Shatat and Udin, 2012). In some academic work, the research object is supply chain integration and collaboration with supply chain partners, but without considering the impact of IT

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(e.g. Kaipia, 2007; Klein and Rai, 2009; Prajogo and Olhager, 2012). The role of IT in SCP was demonstrated impressively when IKEA introduced its centralized planning processes for store replenishment (Jonsson *et al.*, 2013). As APS software has already been on the market for about a decade and the penetration among manufacturing companies is making progress, expertise in IT for SCP is growing. APS software comprises several modules with each module providing a set of functionalities. APS software packages do not always offer the same functionalities, and even if a certain functionality is part of a package, additional costs may occur due to customization, change management or migration (from a legacy system to a new solution). Respectively, the decision problem is based on functional modules and single functionalities rather than a comprehensive APS suite.

Aim and objectives of the research

This investment decision problem about IT systems in SCP has several aspects. The foundation is a clear understanding of the functional domains, which compose the natural building blocks of IT systems in SCP. Furthermore, each functional domain has a couple of main IT functionalities that need to be identified and characterized. Finally, the potential to generate additional revenues and to reduce costs, which are the basic drivers of business value, require a distinct link to the identified IT functionalities. This would qualify supply chain and IT managers to make fact based investment decisions about IT in SCP. Hence, we state the research question as follows:

RQ1. How should supply chain and IT managers set the investment priorities so as to enable SCP to maximize value for the company?

Literature review

Many studies have already demonstrated that IT can make a difference in SCM and creates lasting value. One group of studies detected value generation in revenue, gross margin and profits (e.g. Dehning *et al.*, 2007; Hendricks *et al.*, 2007; Liang *et al.*, 2010). A second group chose a theoretical approach and developed the logic of IT value creation in SCM (e.g. Fasanghari *et al.*, 2007; Schnetzler and Schönsleben, 2007). A third group identified more detailed value-generation levers on an empirical basis, through surveys or case studies (e.g. Akkermans *et al.*, 2003; Auramo *et al.*, 2005; Buxmann *et al.*, 2004; Savitskie, 2007). All these studies focussed primarily on the transactional part of SCM, also called supply chain execution. The other part is SCP, which is more strategic.

Value of IT

There are three important studies, which analyzed the IT value creation in SCM. Auramo *et al.* (2005) demonstrated that e-business solutions improve customer service elements, process efficiency and the agility of the supply network. Savitskie (2007) obtained similar results, showing that internal and external logistics information systems improve performance measures like logistic costs, inventory turnover, order fill capacity, product and order flexibility, delivery time flexibility, and customer satisfaction. Buxmann *et al.* (2004) provided evidence that companies, which implemented IT to support their SCM, have been able to reduce their costs and lead times, and to increase their service levels although the exact magnitude and origin of the value contribution remains unclear.

Optimization type

The planning activities of SCM can be performed and optimized in three different ways: intra-functional, cross-functional and cross-company. The basic method is intra-functional, without collaboration with other business functions or supply chain partners. With the rise of the concept of SCM, decision-making processes started to take a more cross-functional, holistic perspective (Bechtel and Jayaram, 1997). Finally, cross-company optimization is about sharing information with supply chain partners such as suppliers, customers, and logistics service providers (Li and Lin, 2006; Hsu, 2005; Wong *et al.*, 2011). IT plays a critical role in cross-functional and even more so in cross-company information flows (Davenport and Brooks, 2004; Hadaya and Cassivi, 2007; Hübner *et al.*, 2013; Rai *et al.*, 2006).

Penetration level of IT

The adoption of IT in SCM is so far measured on a system basis, and not per functional modules or even main IT functionalities. Buxmann *et al.* (2004) measured the use of SCM software, and found that 50 percent of the respondents had a software tool implemented and about 20 percent planned its implementation. In the sample of Barbosa and Musetti (2010) the adoption rate of ERP systems was 68.5 percent. Ngai *et al.* (2008) came to slightly lower results for the population of Hong Kong-based companies. A more detailed assessment of the penetration level of IT functionalities in SCP is still missing.

Conclusion

While there is plenty of research about the operative part of SCM, little attention has been paid by researchers to SCP. The individual value drivers of IT in SCM are well researched, but empirical insights about its direct impact in SCP is limited. In addition, a comprehensive conceptual framework combining value generation, optimization types and IT penetration in SCP is yet to be developed.

Theoretical background

The conceptual framework of IT value in SCP has a simple structure (see Figure 1). The IT functionalities can be split by two dimensions: functional domains and optimization types. Within these dimensions the measurement is based on penetration level and performance.

Functional domains

The Supply-Chain Operations Reference Model (SCOR) is a process and domain model, which was developed by the Supply Chain Council (see Stewart, 1997). The four main

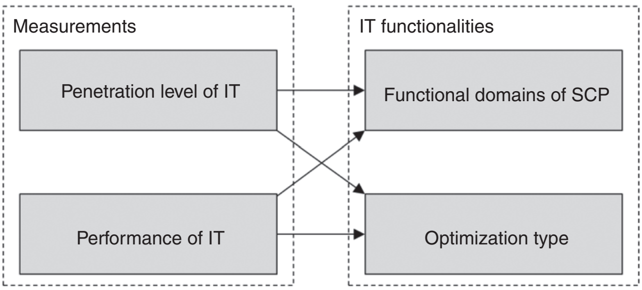

Figure 1. Conceptual framework of IT value in supply chain planning

supply chain processes of SCOR are source, make, deliver and plan. The first three comprise the transactional, short-term supply chain level. Plan, in contrast, has a mid- to long-term perspective. On the basis of SCOR, McLaren and Vuong (2008) developed a functional model by analyzing documentation of SCM software. This model is similar to the APS framework, although the later has a clear focus on the planning processes (see Stadtler, 2005; Meyr *et al.*, 2008). APS consists of nine domains: demand planning, master planning, purchasing and material requirements planning (MRP), production planning, production scheduling, distribution planning, transportation planning, demand fulfillment and ATP, and strategic network planning.

Optimization type

As mentioned above, three basic types can be differentiated, which can be demonstrated at the ATP check (see Figure 2). If the ATP check is performed based the availability of the required product in the inventory, no other function as sales and distribution is involved. An IT functionality that provides increased transparency on inventory levels would optimize this operation in an intra-functional way. If production schedules (expected finished goods at a certain point in time) would be included in the ATP calculation, it is called cross-functional optimization. If delivery capabilities of suppliers are incorporated to assess the feasibility of production schedules and to finally confirm a delivery date of the finished product, we speak about cross-company optimization. Although it is obvious that cross-company optimization is theoretically the most sophisticated and eventually the most advanced optimization, the open question is whether IT plays a significant role.

Penetration level of IT

When a new IT functionality is developed, it is considered as an innovation. Diffusion is the process of spreading the innovation in the target population (e.g. organizations), which fulfills the basic conditions to adopt the innovation. The speed of diffusion depends on the willingness and the ability to adopt (Fichman, 1992). For instance, knowledge barriers or a missing IT infrastructure might prevent the implementation of

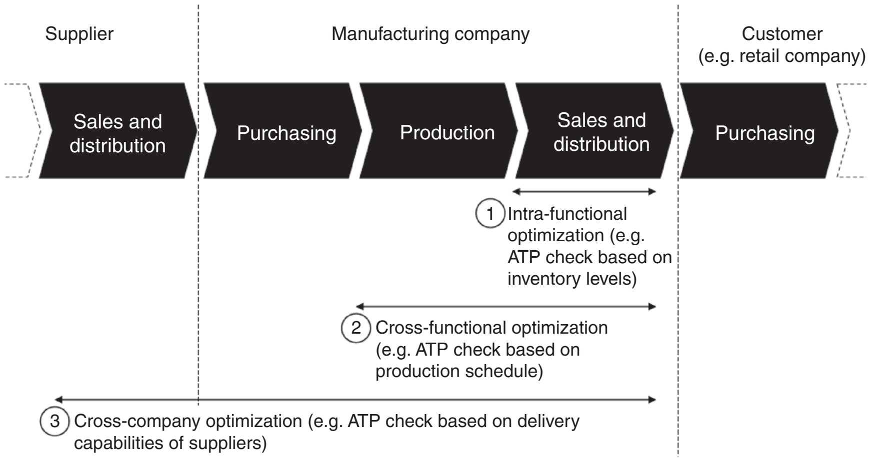

Figure 2.
Intra-functional, cross-functional and cross-company optimization described with the ATP check

the IT functionality. Finally, the penetration level is measured as the quotient of the organizations, which have adopted the innovation, and the total population.

Performance of IT

The productivity increase caused by the use of IT systems is widely discussed. IT helps to improve business processes, which should ultimately lead to a better organizational performance (Melville *et al.*, 2004). Clearly defined performance metrics are necessary to make value creation by IT transparent (Brynjolfsson, 1993). Three basic performance metrics are suitable for this objective:

(1) Customer service. Shorter lead times, increased delivery reliability, flexibility in response to customer requirements, delivery time flexibility, high-order fill capacity, advanced shipment notifications, etc. improve the service delivered to the customer and may ultimately increase the company's revenue (e.g. Auramo *et al.*, 2005; Buxmann *et al.*, 2004; Liang *et al.*, 2010).

(2) Inventory costs. The capital costs of raw materials, work-in-progress and finished goods, as well as the operating costs of running the warehouses comprise the inventory costs (e.g. Beamon, 1999; Dehning *et al.*, 2007; van Horenbeek *et al.*, 2012).

(3) Operational costs. These consist of all costs for distribution, manufacturing, purchasing and administration (e.g. Beamon, 1999; Gunasekaran *et al.*, 2001; Savitskie, 2007).

Research methodology

IT applications for SCP are already in the market for many years. Accordingly, we chose an empirical research design and followed the systematic approach of Flynn (1990) (see Figure 3).

Due to broadly distributed experience with APS, we applied a web survey based on a structured questionnaire, which was conducted between April and June 2012. We contacted 193 supply chain or IT managers of German companies, which manufacture in a continuous production flow (in contrast to disrete manufacturing) with revenues of at least 100 million euros (smaller companies do not have a sufficient IT density). We received 61 responses, but we found 14 to be invalid due to incompleteness, inadequate company profile or too short questionnaire handling time. The number of 47 valid responses is in line with similar work. For example, Auramo *et al.* (2005) surveyed 48 companies and Savitskie (2007) could draw meaningful conclusions with a sample size of 34. The response rate of 24.4 percent is considerably higher than comparable studies (e.g. Barbosa and Musetti, 2010; Buxmann *et al.*, 2004; Savitskie, 2007).

We preferred the APS framework to SCOR, because of its focus on SCP. We grouped the domains production planning and scheduling together as well as distribution and transportation planning, because they are highly interrelated. Within each domain, we identified between five and eight IT functionalities. For example, the IT functionality of statistical forecasting based on historical data is part of the domain demand planning.

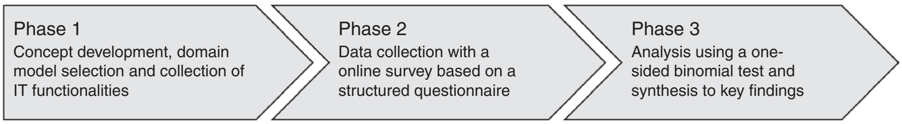

Figure 3. Overall research approach

The domain of strategic network planning was specified as beyond the scope of the study, because IT naturally plays a secondary role in its business capabilities. In addition to this domain framework, all IT functionalities are directly allocated to one of the three optimization types from Figure 1 based on their inherent characteristics: intra-functional, cross-functional and cross-company.

For each IT functionality, the survey participants were asked whether they had implemented the functionality, are planning to do so or have not implemented it (and are not planning to do so). If the participant has implemented the IT functionality within the last eight years or planned its implementation, the person was asked to respond to three consecutive questions:

(1) What was/is the (expected) payback period of the investment? (response options, single selection: < 3 years, > 3 years or negative).

(2) Which, if any, of the following performance indicators have been/will be improved? (response options, multiple selection: customer service, inventory levels, operating costs).

(3) Which of the following software type was/will be implemented? (response options, single selection: self-developed, packaged standard software).

The participants were not obliged to respond with respect to all domains, because not every supply chain manager knows all the IT systems in the field of SCP. On average each participant responded to the questions of three to four domains (out of six). In total, the 47 respondents addressed 858 individual IT functionalities (implementation status) and 350 sets of subsequent questions (payback, performance indicators and software type). Functional modules constitute a different option for the unit of consideration (e.g. a software module for demand forecasting). We prefer IT functionality to functional modules as our unit, because we want to take account of the functional breadth and depth of implemented software. Our aim is to measure not only the functional breadth of how many modules are implemented to cover the SCP domains, but also to address the functional depth of how much IT functionality is implemented within each domain. In the statistical tests, we compared the results of the domains and the optimization types against the average for the entire sample. As the test problem is binominal, our sample size large and the π[1] around 0.5, we used the one-sided binomial test approximated with a normal distribution.

Participant characteristics

Our respondents are distributed quite equally into consumer goods (including food and beverages) and other industries (see Table I). In terms of size, the sample is quite representative for the German continuous production flow industry. We can roughly estimate the total revenues for the sample, if we multiply the number of companies with the average revenue for each category. The result is about 87 billion euros. The German GDP share of the manufacturing industry (including non-continuous production flow industry) is 525 billion euros in 2011. Thus, our sample comprises at least one sixth of the total population.

Data analysis and results

Validity analysis

We expected that there could be differences in the perception of IT value between employees of the IT and the supply chain department. IT employees could have an

	Number	% of total
Industries		
Chemicals	15	31.9
Food and beverages	14	29.8
Other continuous flow industry (paper, basic raw materials, etc.)	9	19.1
Pharmaceuticals	6	12.8
Other consumer goods	3	6.4
Size		
100-500 million EUR	19	40.4
500 million-1 billion EUR	14	29.8
1-5 billion EUR	10	21.3
5-10 billion EUR	1	2.1
> 10 billion EUR	3	6.4
Position		
Head of SCM	11	23.4
Other employee of SCM	11	23.4
Head of IT	9	19.1
Other employee of IT	11	23.4
Other	5	10.6
Years at company		
< 2 years	3	6.4
2-5 years	8	17.0
> 5 years	36	76.6

Note: $n = 47$

Table I. Respondent demographics

overconfidence bias that IT delivers a higher value than is actually the case. But at a significance level of 0.05 we are able to deny this possible overconfidence bias.

It is arguable whether companies which are planning to implement IT functionality should be asked about the expected benefits of the investment. On the one hand, they have analyzed the consequences of the IT implementation in terms of costs and benefits (although the level of detail may vary). On the other hand, they could overestimate the positive impact, because not all potential improvements might be realized or they merely want to justify the implementation of something which they want subjectively (see Lovallo and Kahneman, 2003; Selart *et al.*, 2008). Looking at our results, we observe that realized investments are rated equally valuable to planned IT implementations at a significance level of 0.01. Given that optimism bias about investment forecasts is not present in our sample, we combine the data for planned and realized implementations when analyzing the payback period and the performance indicators. We applied the extrapolation method of Armstrong and Overton (1977) to analyze the non-response bias. No significant differences in the results were found at the 0.01 level.

Study results

On average, 42 percent of the provided IT functionalities to support SCP are actually implemented, 11 percent are planned and 47 percent are not implemented (see Table II). The results across the different domains do not differ significantly with one exception: demand fulfillment and ATP. In this domain, the implementation level is lower, at a significance level of 0.05. Greater differences in the results were found in the split by optimization type. Intra-functional optimization has a higher and cross-company optimization a lower implementation level than the average.

	Implemented functionality (%)	Implementation planned (%)	Not implemented (%)	p-value[a]
Total ($n=858$)	42.1	10.8	47.1	
Split by domain				
Demand planning ($n=200$)	39.5	12.0	48.5	0.630
Master planning ($n=151$)	40.4	13.9	45.7	0.336
Purchasing and MRP ($n=135$)	36.3	16.3	47.4	0.504
Production planning ($n=142$)	48.6	9.2	42.3	0.108
Distribution and transportation planning ($n=111$)	53.2	6.3	40.5	0.069
Demand fulfillment and ATP ($n=119$)	37.0	5.0	58.0	0.011*
Split by optimization type				
Intra-functional ($n=382$)	50.5	9.9	39.5	0.001**
Cross-functional ($n=252$)	40.5	11.1	48.4	0.640
Cross-company ($n=224$)	29.5	12.1	58.5	0.000**

Notes: [a]Of implemented functionality and implementation planned jointly. *,**Significant at the 0.05 and 0.01 levels, respectively

Table II.
IT density

Table III shows the value of IT investments. Almost 70 percent of IT investments have a payback period of less than three years. The domain with the lowest penetration level, demand fulfillment and ATP, has the highest IT value. With about 85 percent of investments having a payback period of less than three years, it is significantly higher than the sample average. In addition, the value of distribution and transport planning is, at 78 percent, also significantly above the average. The IT value of the other four domains is at the sample average. With the split of optimization type there are no observable significant differences to the average.

The analysis of value drivers (performance indicators) yields a differentiated picture (see Table IV). On average, customer service was improved in 60 percent of the cases. Domains that delivered significantly higher results are demand planning and demand fulfillment and ATP. Lower results were obtained for purchasing and MRP and

	Payback <3 years (%)	Payback >3 years (%)	p-value
Total ($n=350$)	68.3	31.7	
Split by domain			
Demand planning ($n=91$)	62.6	37.4	0.148
Master planning ($n=63$)	58.7	41.3	0.070
Purchasing and MRP ($n=52$)	69.2	30.8	0.390
Production planning ($n=60$)	70.0	30.0	0.341
Distribution and transportation planning ($n=58$)	77.6	22.4	0.044*
Demand fulfillment and ATP ($n=26$)	84.6	15.4	0.017*
Split by optimization type			
Intra-functional ($n=192$)	69.3	30.7	0.358
Cross-functional ($n=91$)	64.8	35.2	0.273
Cross-company ($n=67$)	70.1	29.9	0.328

Note: *Significant at the 0.05 level

Table III.
Value of IT functionality

Table IV. Improved performance metrics by IT functionality

	Better customer service		Lower inventory levels		Lower costs	
	Relative (%)	*p*-value	Relative (%)	*p*-value	Relative (%)	*p*-value
Total ($n = 350$)	59.7		66.0		72.6	
Split by domain						
Demand planning ($n = 91$)	78.0	0.000**	79.1	0.002**	52.1	0.000**
Master planning ($n = 63$)	54.0	0.211	66.7	0.409	87.0	0.001**
Purchasing and MRP ($n = 52$)	42.3	0.008**	80.8	0.006**	82.8	0.031*
Production planning ($n = 60$)	48.3	0.049*	73.3	0.089	79.7	0.072
Distribution and transportation planning ($n = 58$)	53.4	0.200	36.2	0.000**	84.4	0.011*
Demand fulfillment and ATP ($n = 26$)	84.6	0.001**	38.5	0.004**	51.6	0.004**
Split by optimization type						
Intra-functional ($n = 192$)	57.8	0.320	67.2	0.338	75.5	0.159
Cross-functional ($n = 91$)	60.4	0.405	68.1	0.298	71.4	0.443
Cross-company ($n = 67$)	62.7	0.269	58.2	0.113	65.7	0.130

Note: *,**Significant at the 0.05 and 0.01 level, respectively production planning. A reduction of inventory levels was achieved for 66 percent of the IT investments. Especially in demand planning and purchasing and MRP, new IT functionality led significantly more often to lower inventory levels. Distribution and transportation planning and demand fulfillment and ATP resulted in fewer cases of lower inventory levels. The performance indicator that was improved in most cases was operating cost (73 percent). The domains master planning, purchasing and MRP, and distribution and transportation planning delivered significantly higher results. Lower results are evident for demand planning and demand fulfillment and ATP. In the analysis of optimization type, none differed significantly from the sample average in all three performance indicators.

Overall, more than three-quarters of the IT functionality was implemented using standard software packages (see Table V). Demand planning is above the sample average at 88 percent, while distribution and transportation planning is significantly lower at 64 percent. We observe no significant differences in the results of the optimization types.

The data analysis has identified significant deviations from the average of the sample in all considerations, which indicates interesting findings. These are discussed in the following chapter.

Discussion and research synthesis

This study enhances our understanding of how APS solutions are used and their added value. Additionally, to the best of our knowledge, the study is the first to deal with the IT contribution to a core principle of SCM, namely breaking up functional (cross-functional optimization) and organizational boundaries (cross-company optimization) to optimize business performance with respect to the end customer.

IT density

We observed an overall implementation level of almost 50 percent of provided functionality. These results are comparable to the study of Buxmann *et al.* (2004). Interestingly the results do not differ significantly between the various domains of SCP. Only demand fulfillment and ATP has slightly lower results. The reason for this

	Packaged software (%)	Individual software (%)	*p*-value
Total ($n = 350$)	76.3	23.7	
Split by domain			
Demand planning ($n = 91$)	88.5	11.5	0.001**
Master planning ($n = 63$)	68.4	31.6	0.109
Purchasing and MRP ($n = 52$)	73.1	26.9	0.341
Production planning ($n = 60$)	77.2	22.8	0.387
Distribution and transportation planning ($n = 58$)	64.0	36.0	0.034*
Demand fulfillment and ATP ($n = 26$)	81.8	18.2	0.199
Split by optimization type			
Intra-functional ($n = 192$)	75.4	24.6	0.418
Cross-functional ($n = 91$)	73.9	26.1	0.333
Cross-company ($n = 67$)	82.8	17.2	0.091

Note: *,**Significant at the 0.05 and 0.01 levels, respectively

Table V.
Software type

phenomenon may be that the benefits of its business capabilities are not as tangible as those of other domains.

We identified more significant differences by comparing the implementation level across the three optimization types. IT functionality to support intra-functional optimization is more frequently implemented as the average, while cross-company optimization has significantly lower results. Supply chain and IT managers of process industry companies seem to follow a natural implementation path. Basic IT systems standardize processes, harmonize data, accustom employees to IT tools and, of course, yield the first tangible benefits. As soon as the solutions are stable, managers take the next step and look beyond their own function. After optimization within one's company is complete, firms start collaborating with suppliers, customers and other supply chain partners.

Origin and size of IT value

The domain with the lowest penetration level, demand fulfillment and ATP, has the highest IT value. Our data demonstrate that having the ability to allocate products in stock to orders and to promise a reliable delivery date to customers is very beneficial. Almost 90 percent of IT functionality in demand fulfillment and ATP improve the performance indicator customer service. Reliable and fixed delivery dates avoid lost sales, and deeper integration and collaboration with customers increase sales opportunities and contributes to long-term business relationships.

Although the value of demand fulfillment and ATP solutions is outstanding, the other domains also provide substantial value creation potential. In all domains, more than 50 percent of IT investments are paid back within three years. The results provide evidence that for all tasks within SCP an IT support is valuable.

Regarding the optimization type, no significant differences were found. IT functionalities for cross-company optimization have, on average, slightly lower payback periods, but the difference between these and intra-functional and cross-functional optimization is, in our sample, not significant. Accordingly, each optimization step has a substantial value potential. This can be demonstrated at a business capability in purchasing and MRP: purchase decisions. An IT solution that supports purchase decisions not integrated with third parties or other supply chain domains like production planning pays back within three years in 80 percent of the cases. An integrated solution with other domains is slightly less valuable, with roughly 50 percent of paybacks within three years. Such a solution is usually much more expensive, but does not provide significantly higher benefits than the basic solution. The most sophisticated solution of integrating with suppliers to optimize the total cost of ownership (TCO) for both supply chain partners also has a payback within three years in 80 percent of the cases. Although we expect such an integrated IT system to require the greatest upfront investment, it seems to reduce inventory levels and operating costs on a similar scale.

Value drivers

The IT support in the different domains has a diverging impact on the performance indicators of customer service, inventory levels and operating costs. These performance indicators drive the value that is reflected in the payback period. An improvement in customer service can be achieved by implementing IT functionalities in demand fulfillment and ATP (improvement in 89 percent of IT investments) and demand planning (82 percent). These are the domains which interact directly with customers.

An IT-supported assignment of stocked products to customer orders avoids mistakes and increases the reliability of availability promises. Especially the already mentioned possibility to segment customers in the assignment process adds considerable value. It provides the opportunity to give higher margin customers priority order delivery.

Key domains for significantly lowering inventory levels are: purchasing and MRP (reduction in 81 percent of IT investments), demand planning (79 percent) and production planning (73 percent). Within purchasing and MRP, the best functionality for lowering inventory is a purchasing order decision tool that is integrated with master and production planning. This enables a long-term matching of material requirements and purchasing planning instead of short-term approaches (e.g. safety stocks, etc.). An IT-supported demand forecasting avoids the risk of overproduction. Good product lifecycle planning ensures that products, which are phased out of marketing, have slower or even terminated production. IT functionality implementation in production planning helps to reduce inventory levels of all types of materials and products.

The top three domains, where IT functionality particularly helps to reduce operating costs, are master planning (reduction in 87 percent of IT investments), distribution and transportation planning (84 percent) and purchasing and MRP (83 percent). A well-supported sales and operations planning and rough-cut planning of production quantities ensures production at the lowest TCO, with respect to manufacturing productivity, material and logistic costs. It is obvious that IT functionalities in the distribution and transportation domain reduce logistic costs. Additionally, certain IT functionalities – like the calculation of transportation quantities and frequencies or an automatic information exchange with suppliers, customers, and logistic providers – reduce personnel costs more than IT functionalities of other domains.

Software type

The use of packaged standard software is dominant with a share of 76 percent. Individual, self-developed software is only implemented in rare cases with very company-specific requirements. Furthermore, the trend is toward even more packaged software. Additionally, it should be mentioned that we did not observe any significant difference in value creation between packaged and individual IT solutions.

Conclusion

The results of our study demonstrate that IT plays an important role in SCP. Overall our empirical insights include:

- IT functionality for SCP is implemented to a medium degree;
- the value of IT functionality in SCP is high;
- implementations in demand fulfillment and ATP have the biggest value creation potential, although its current penetration level is low;
- each supply chain performance indicator can be improved by investments in certain functional domains;
- packaged standard software is widely distributed and should be considered as the first option; and

- IT functionality to improve intra-functional processes is significantly more often implemented than IT functionality for inter-functional or cross-company process optimization although the realized value is the same.

The results complement the findings of Buxmann *et al.* (2004), which discovered companies significantly reducing costs and improving customer service by implementing SCM software. Furthermore, Auramo *et al.* (2005) saw companies implementing integrated e-business solutions to substantially improve customer service. Our results indicate improvements in customer service for integrated but also for intra-functional or cross-functional solutions.

Managerial implications

In the context of our research question, IT and supply chain managers in companies with a continuous production flow should continue or even increase IT investments in SCP. The potential value is tremendous (compare Buxmann *et al.*, 2004). Companies should first analyze which performance indicators are behind their targets and then implement IT solutions in those domains, which offer potential improvements to these performance indicators. For instance, if a company wishes to reduce inventory levels, they should invest in IT functionality in purchasing and MRP and demand planning. Furthermore, companies should start with basic IT solutions that optimize operations within a certain function, and then look at cross-functional and cross-company solutions (compare Hadaya and Cassivi, 2007). Moreover, our results indicate that there is no reason why customized IT solutions should be implemented. Only if there are exceptional, compelling reasons, an individual solution should be taken into consideration.

Conceptual findings

The conceptual framework has been proven as robust and practical in the application. The domains of the APS framework exhaustively cover the functions of SCP. With the progress of IT, also the domain of strategic network planning can be considered in IT value assessments in SCP. The rise of big data might enable IT functionalities that significantly improve the performance of the operations in strategic network planning. The performance indicators customer service, inventory levels and operational costs cover the most significant value contributors. Especially customer service could be broken down into its components (e.g. shorter lead time, increased flexibility) for a more detailed analysis (compare Savitskie, 2007). Overall, the conceptual framework is well balanced between theoretical thoroughness and practicality for empirical research. Depending on the objective, future research can enhance the framework in both directions.

Limitations and future work

Our study has some limitations. First, it is limited to Germany. Second, the survey is based on personal perceptions and did not collect hard facts like implementation costs or measured benefits. Third, it was an online survey, which can entail some misunderstandings or technical issues. However, the findings present an opportunity to further develop our understanding of the role of IT in SCM. First of all, the results could be validated by a survey outside Germany. A similar study in the industries of discrete manufacturing would be very interesting, given that SCP is less important there.

Finally, as IT is so valuable in SCP of companies with a continuous production flow, it would be very beneficial to develop new IT functionalities.

Note

1. π is the expected proportion of a positive characteristic (e.g. if π of "Payback $<$ 3 years" is 0.7, it means that on average, 70% of IT implementations have a payback within less than three years)

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