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Diffusion of IS in companies using renewable resources and its impact on uncertainty

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ABSTRACT

The importance of sustainability is meanwhile well known in research as well as in practice. One way to produce more sustainable goods is the use of renewable resources. In this paper we present a two-staged study, consisting of a quantitative survey followed by qualitative interviews with companies which use renewable resources as an input for production. The focus of our study is on the diffusion of IS and supporting technologies and concepts in these special industrial sector. Due to the natural growth and environmental influence factors it can be supposed that renewable resources are underlying a greater uncertainty regarding quantity, quality and time of availability. Therefore we also examine the influence of IS on uncertainty in the companies surveyed.

Keywords

Green through IS, Small and mid-sized enterprises, renewable resources, uncertainty, technology diffusion.

INTRODUCTION

Sustainability and Greenhouse gases are hot topics in the IS-community. These contemporary issues are compromised to the keyword Green IT, which mainly focuses on IS as energy consumers and polluters which should be operated more efficient and decrease CO_2 emissions (Park, Cho, Shim, Kim and Lee, 2009; Schmidt, Erek, Kolbe and Zarnekow, 2009). While most of the papers in this area reduce their focus to emissions, energy consumption or carbon footprinting, a new research direction is seen by Melville (2010) in Green IS, which examines Information Systems as an enabler of more sustainable processes by measuring, supporting and controlling them more efficiently. When this idea is thought a step ahead IS could even help to make products greener by supporting or even enabling resource-efficient processes, for example production processes with renewable resources. This direction can be seen as "Green through IS" (Heng, Klusmann and Koenig, 2011; Park et al., 2009), where IS (possibly) is not green itself but serves as an enabler for greener production by supporting processes and organizing them.

Renewable Resources can make products more sustainable due to their CO_2 neutrality within their whole life cycle and help to achieve an overall better environmental footprint (Berndes, 2006; Kaplan, 1998; Narodoslawsky, 2003). Besides the environmental aspects there is one important point from the business perspective: renewable resources are available in the long run and can be produced according to plan – there is no exhaustion compared to other natural or synthetic materials. The large industry companies use more and more renewable resources in their products: Mercedes-Benz uses up to 43 kilogram of natural fibers in their cars (DaimlerChrysler Communications, 2008), Toyota integrates Bioplastics made of soy or other starchs in their seats and interiors (Connell, 2008) and BASF points out the resource change as one of their future markets (BASF, 2009). Many more examples can be found in other industries and products.

But how can IS really support the planning and handling of renewable resources to get Green through IS? At first there is one important restrictive factor: the diffusion and utilization of IS itself in the companies and along the supply chain. Regarding production companies, the use of planning methods is of interest as well. Furthermore it is of crucial interest what the basic attitude of industries towards the theoretical driven approaches of Green (through) IS is and if they are willing to use IS for

this purpose. In this paper we present an explorative field research consisting of a survey and interviews with companies which use renewable resources as an input factor to find out which systems and software they use and if planning concepts are implemented. Beside this main goal of our study, showing the status quo, interviews should shed more light on the findings and will reveal some discrepancies which hinder the implementation of Green through IS. We can just show a first insight into this topic, because the further research is still in progress.

The paper is organized as follows: First we give some information about the theoretical background and our research questions. Afterwards the methodology for the field research and the collected data set is described. The findings of the survey and interviews are presented in the following section. The article ends with a conclusion and implications for further research.

THEORETICAL BACKGROUND AND RESEARCH QUESTIONS

Conventional supply chains have been widely discussed in the scientific literature. Methods and concepts like Supply Chain Management (SCM), Supply Chain Event Management (SCEM), Collaborative Planning, Forecasting and Replenishment (CPFR) or Advanced Planning and Optimization (APO) are well known and established in theory and practice. The same is true for the supporting or enabling IS and standards like ERP-Systems (Enterprise Resource Planning), Electronic Data Interchange (EDI) or Radiofrequency Identification (RFID). As we want to examine the diffusion of IS in companies using renewable resources or the supply chain respectively, we will have a closer look at general studies of technology diffusion first. After that we provide some basics about renewable resources and our understanding of small- and mid-sized enterprises. At last we present our research questions.

Technology Diffusion and Adoption

The IS literature offers a wide range of theories and case studies regarding the adoption and diffusion of technology in companies. For a general overview of technology diffusion from a macro level and influencing factors we want to relegate the interested reader to Cavusoglu, Hu, Li and Ma (2010). Since the 80s the research on adoption of technology in business has been done by using case studies (Fichman, 1992). Most of the studies reveal key factors for the success of IT-adoptions: Fichman points out that the place of adoption affects the diffusion (1992) and Grover, Teng, Segars and Fiedler show that the adoption depends on IT complexity and can have a positive impact on productivity and processes (1998). Most case studies were carried out at large companies, as it is more probable to adopt new technologies there (Martins and Oliveira, 2007).

While most of the studies analyze the IS diffusion in general, some more specific studies concerning the diffusion of certain technologies were done as well. It is noticeable that most studies were carried out in the early stages of the technology's lifecycle to evaluate positive factors for diffusion and to find some models for later adopters, as done by Premkumar, Ramamurthy and Nilakanta in the case of EDI (1994). New emerging technologies like RFID gain a great interest in scientific literature, especially the potential diffusion strategies (Schmidt, Thoroe and Schumann, 2010). The implementation of software like ERP is studied for large companies (Karimi, Somers and Bhattacherjee, 2007; Sarkis and Sundarraj, 2003) as well as for small companies (Liang and Xue, 2004).

In the area of small or medium sized companies only some scattered studies were done, most of them regarding a certain kind of technology. Premkumar and Roberts examined the usage of the Internet and influencing factors of adoption in rural small and medium-sized enterprises (SMEs) in the United States (1999); Grover and Goslar examined the diffusion of telecommunication technologies more general in the United States (1993). The organizational factors, innovation characteristics and CEO characteristics which lead to adoption of Information Systems in small businesses were examined by Thong (1999). To our best knowledge a study about the actual implementation of IS technologies and related concepts in the industrial sector of companies which use renewable resources has not been done yet.

Renewable Resources and their uncertainty

In contrast to natural resources, which can be exhausted, renewable resources are naturally occurring resources which are either auto-generated within a natural system or grown by agriculture and silviculture. They can be produced systematically so that they are not exhausted. The industrial production can use renewable resources for energetic or recycling use. In energetic use the raw material is used to produce energy or heat. In recycling use the raw material or some of its components are used to produce other material products. Renewable resources have the advantage of being bio-degradable and CO_2-neutral throughout their entire life-cycle (Minol and Sinemus, 2004; Mohanty, Misra and Drzal, 2002). This leads to an increased industrial use of resources like wood, cereals and plant fibers. Willows and poplars are grown preferably in short-rotation plantations by forestry to be used as energy crops. Another thriving area for renewable resources are the so-called bio-synthetics or bio-polymers (Kaplan, 1998; Mohanty et al., 2002), for the production of which mainly chitin, keratin,

lignin, casein, gelatin and sugar are used. The Supply Chain of agricultural and forestry products differs from conventional supply chains: Most of the original producers of the resources are small-sized, followed by regional sales intermediaries or refiners and as a last step the manufacturing industries. The different charges are mixed due to their consistency and transportability (bulk goods) at several stations of the supply chain, for example in silos, trucks, trains and in the production, where raw materials of different origin may be included. An exemplary supply chain of renewable resources which are processed by refiners (e.g. wood or fibers) is shown in Figure 1.

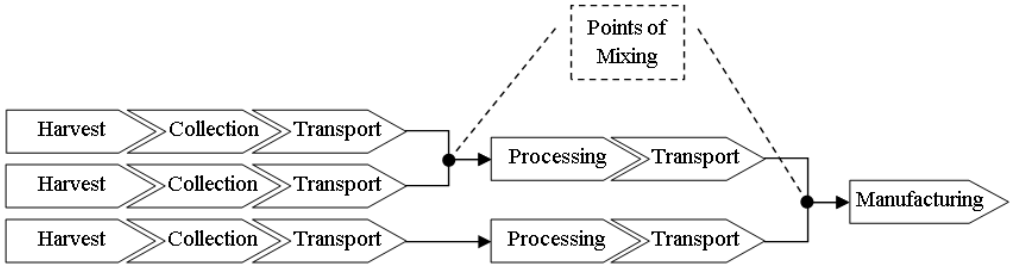

Figure 1. Exemplary Supply Chain of renewable resources

It can be presumed that this supply chain and the relevant planning is faced with more uncertainty as the natural growth processes make it difficult to ensure exact times, quantities and qualities of harvests (Dennis, Brown, Stage, Burkhart and Clark, 1985; Narodoslawsky, 2003; McCarthy and Burgman, 1995). Uncertainty and risk differ to the extent that probabilities can be specified for certain scenarios under risk (Knight, 1921). In our study we do not differentiate between these two words, as the need for action is independent from probabilities. Thus we will use the word uncertainty as a more generic term and define it as every non-influenceable, unplanned and external event. The dependency on variables that cannot be influenced, such as precipitation, solar radiation or infestation by pests create new uncertainties in the supply of raw material, which are not or not sufficiently taken care of in conventional supply chains and in production planning (Krupinsky, Bailey, McMullen, Gossen and Turkington, 2002). Complete losses of harvests, e.g. through natural disasters, droughts or pest infestations will certainly be a rare occurrence. However, deviations from plan are more likely the more accurate plans are made (e.g. the just-in-time-production with small time slots). This leads to a discrepancy between production planning and uncertainties in the time of availability of renewable resources. In the case of quality, uncertainties result from differences in size, material defects or damages and divergences from the defined requirements towards raw materials as required by the production process. Similar reasons lead to fluctuations of the harvested quantities. Furthermore, qualitatively inadequate raw materials cause more quantitative uncertainties as low-grade raw materials cannot be used for production. Climate change and sudden events do not only influence the availability of resources, but also transport routes and infrastructures, e.g. forest roads, and therefore the whole supply chain (Nöthinger and Caluori, 2009).

Small and medium-sized enterprises

For our study, we draw upon the definition of small and medium-sized enterprises of the European Commission for Enterprise and Industry. The key differentiators are the number of employees and the turnover or balance sheet total. Small enterprises have less than 50 employees and a turnover of less than 10 Million Euro while medium-sized enterprises have less than 250 employees and 43 Million Euro turnover (European Commission, 2010). Large enterprises have therefore more employees and turnover. We use the number of employees and the turnover as differentiators because these parameters are expected to be better known by all participants of our study and are generally available.

Research Questions

We intent to get an idea of the diffusion and usage of IS in companies which use renewable resources. As we suppose that most of these companies are small or mid-sized like most German companies and perceive uncertainties as mentioned above due to the renewable resources, the first research question deals with the structure of the companies. Our definition of uncertainty was presented to the participants and they should answer in respect to their perceived uncertainty referring to the input factors. We also consider the supply chain and the import area to gain a brief overview of the supply chain and its impact on uncertainty.

Question 1: Are most of the companies small or mid-sized and do they perceive uncertainty in their supply chain?

The next questions should clarify the usage both of IS technologies or software and of planning concepts supported by these technologies in the companies:

Question 2: Which IS technologies are implemented in the companies?

Question 3: Which planning concepts are used in the companies?

As mentioned before, the supply chain of renewable resources and the production planning is subject to more uncertainties than in the conventional supply chain. At last we will have a look at the question whether the implementation of IS technologies and concepts can help to achieve a safer planning and usage of the renewable resources:

Question 4: What is the impact of IS and/or concepts on the uncertainty in planning and usage of renewable resources?

METHODOLOGY

As there is no knowledge about the supply chain and IS in companies using renewable resources, we conducted an explorative field research. The first step was an online survey of members of the focus group, which is described below. Participants were asked if they are willing to participate in a telephone interview, which is the second step of our field research. While the survey as a quantitative method should give some basic insights, the telephone survey in the form of a structured interview as a qualitative method should result in deeper knowledge about the raised questions. The results of the telephone interviews were documented as case studies (Benbasat, Goldstein and Mead, 1987).

Case studies are well known and established in the IS literature (Lee, 1989). They are especially useful to understand the development, implementation and usage of IS in the field and are mostly used when there is no or little knowledge to reveal a deeper insight into the topic (Cavaye, 1996; Darke, Shanks and Broadbent, 1998). Other authors agree upon these understanding and point out the "real-life context" (Yin, 1994), "natural, real-world setting" (Lee, 1989) and the "exploration of unknown fields" (Cavaye, 1996) or "capturing the knowledge of practitioners" (Benbasat et al., 1987) as well. When conducting research with case studies, there are some disadvantages of this method: Companies or other subjects may not be willing to participate or are not able to answer the questions, the data set is somewhat subject to the researcher and it is difficult to generalize the research results (Darke et al., 1998). As we first conducted a quantitative survey and asked the participants if they are willing to take part in a telephone interview for a case study, we tried to avoid the first two disadvantages. If the subjects agree to participate in the telephone interview, they are willing to and capable of answering questions regarding our research questions. This aspect is strengthened by our letter in which we asked to fill out the questionnaire only if the subject is capable to do so. With this approach we can achieve an appropriate unit of analysis according to Benbasat et al. (1987). By the combination of a quantitative survey and qualitative case studies we try to gain more generalizable results. The results can be checked against each other. This approach is also recommended in IS literature with the topic of field research (Darke et al., 1998; Lee, 1989; Yin, 1994).

To gather an appropriate sample, we first defined the focus group as companies which use renewable resources, according to the definition above, as an input factor. Since we wanted to avoid the aforementioned disadvantage of a subject data set the sample of our study was generated by an explorative procedure which consisted of two parts:

1. The biggest German companies listed in the two stock indexes DAX and MDAX
2. The small and medium-sized companies in German-speaking countries listed in classified directories from the government and business associations[1]

These lists were reduced by deleting all companies which do not use renewable resources as an input according to their websites or self-statements. This explorative approach yielded a list of 792 companies from different industries and different sizes. The companies were contacted by email and asked to complete an online survey with different questions regarding their company, their use of renewable resources, uncertainty caused by the use of these resources, the corresponding supply chain and IS-support. Turnover and number of employees were asked as demographic variables and to categorize into small, medium and large companies.

From Nov. 29, 2010 until Dec. 24, 2010 an amount of 75 participants completed the whole survey (response rate 9.5 %). The collected sample consists primarily of producing industries (48 companies) and building industries (13). Other industries are energy and heat production (5), agriculture/silviculture/fishery (3) and mining or nonmetallic mineral processing (2). The most used renewable resources are wood, fibers, cellulose, vegetable oil and wax.

[1] Fachagentur Nachwachsende Rohstoffe e. V. (FNR); Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV); Öko Plus AG - Fachhandelsverbund für ökologisches Bauen und Wohnen; Verband Deutscher Papierfabriken e. V.; Sachsen-Leinen e. V.

FINDINGS

Regarding the research questions mentioned above the findings of the online survey and the telephone interviews will be described in the following part.

Question 1: Are most of the companies small and mid-sized and do they perceive uncertainty in their supply chain?

The online research was conducted with 68 % small-sized enterprises with less than 49 employees. In contrast, 12 % of the companies surveyed had 1.000 employees or more. In regard to the companies' turnover the survey reveals that more than 50 % have a turnover between 100,000 and 5 Million Euro, what can be regarded as an indicator for the importance of small-sized enterprises in this area (European Commission, 2010). 21 % indicated that their annual turnover is higher than 10 Million Euro.

The analysis of the findings shows that 73 % of the companies use international imports of renewable resources. Countries like France and Spain seem to be favored producing regions for several types of plants. 11 % procure their resources from national partners and 14 % get their resources from the nearby region (see Figure 2).

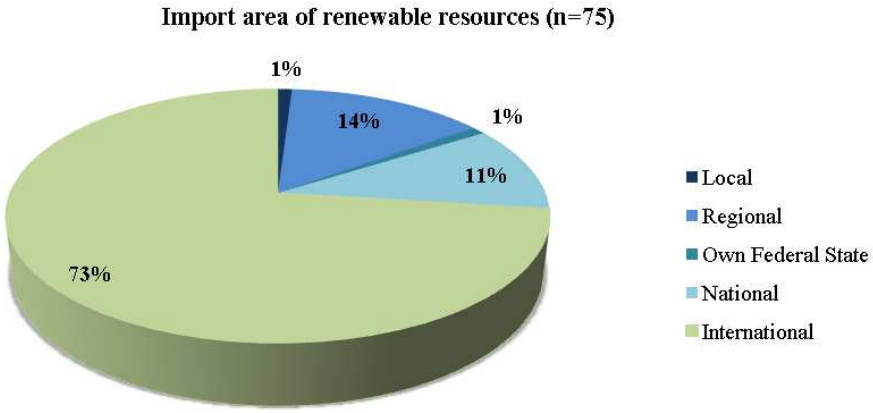

Figure 2. Import area of renewable resources (relative description, single choice)

A cross tabulation of the item "Do uncertainties arise in the supply chain when using renewable resources?" and the size of the import area reveals that there is little tendency that companies which perceive uncertainties in their supply chain have an international import (76.2 %). But because of missing significance (Chi^2=.936) the results cannot be confirmed statistically (see Table 1).

The qualitative telephone-interviews, conducted with four participants, can be seen as an enlargement to the given information of the quantitative research. Concerning their import area the participants told us that enterprises rarely procure their resources from one cultivator in one country, but often have different sources of supply so that there is diversification of the uncertainties.

As a result to research question 1 it can be summarized that the majority of the survey members are small- and mid-sized enterprises of the producing industry and building sector, which procure the renewable resources from international partners.

Concerning the characteristics of the focus groups the qualitative interviews give a detailed overview over different aspects like the use of renewable resources in the company, their supply chain, the application of IS and their final judgment on renewable resources. The main findings are resumed in Table 2.

Source of Supply crossed with Uncertainty perception					
			Do uncertainties arise?		Total
			Yes	No	
	International	number	16	38	54
		% inside of uncertainty perception	76.2 %	70.4 %	72.0 %
Total		number	21	54	75
		% inside of uncertainty perception	100.0 %	100.0 %	100.0 %

Table 1. Abridgement of Cross-Tabulation "Source of Supply crossed with Uncertainty perception"

	Company I	**Company II**	**Company III**	**Company IV**
Industry	Building industry	mining & nonmetallic mineral processing; producing industry	Energy & heat production	Producing industry
Enterprise size (employees; turnover in EUR)	Small company (50-199; n.s.)	Small company (17; 1-5m)	Small company (6; 1-5m)	Small company (0-49; 500,000-1m)
Renewable resources	hemp	hemp	sunflower, canola, jatropha	straw, wood, reed, pampas grass
Utilization since	1996	2010	2002 (since foundation)	2004 (since foundation)
Final product	Insulating material	Plaster	Veg-oil and biofuel	Straw-umbrellas
Supply Chain	Cultivator → factory of fiber-conditioning → company → retailer → end costumer	Cultivator → factory of fiber-conditioning → company → end costumer	Cultivator → agrarian wholesaler → company → industry → end costumer	Cultivator → intermediary (storage) → company → end costumer
Utilization of IS along SC	No, just an internal control-system is used	No, IS are not needed. Even if enterprise was bigger	No	No, just an internal control-system is used
Judgment of renewable resources	Positive because of CO_2 neutrality	Positive because of good quality and long-life cycle	Ideologically positive, economically critical	Positive but no increased utilization in the future

Table 2. Overview over main findings of the qualitative interviews

Question 2: Which IS technologies are implemented in the companies?

A deeper interest of the survey was in the utilization of IS technologies that are implemented in the companies. A first analysis shows that there are very little technologies used in the small- and mid-sized enterprises. It has to be mentioned that for this question multiple answers where possible, so that the number of the given answers is higher than the number of participants who answered the question. The most used technologies are SCM/SCEM (18 % of the companies surveyed) and ERP-systems (17 % of the companies surveyed) (see Figure 3). More complex technologies like APO-Systems are only used by mid-sized and large enterprises. While certain technologies like RFID have been well studied from a scientific point of view and have also been tested in practice with an application for renewable resources (Beplate-Haarstrich, Steinmeier, von Hörsten and Lücke, 2008; Dykstra, Kuru and Nussbaum, 2003; Korten and Kaul, 2008; Sirkka, 2008), our study shows that they are not adopted in the enterprises surveyed.

Question 3: Which planning concepts are used in the companies?

Along with the results of question 2 the results belonging to research question 3 reveal little interest in planning concepts to support or improve the supply chain and the planning. Nearly 10 % of the companies use MRP-systems and 7 % use CPFR, whereas 70 % do not use any planning concept (see Figure 4). While MRP is used in companies of every size, CPFR and the SCOR-Model are used predominantly by mid-sized and large enterprises.

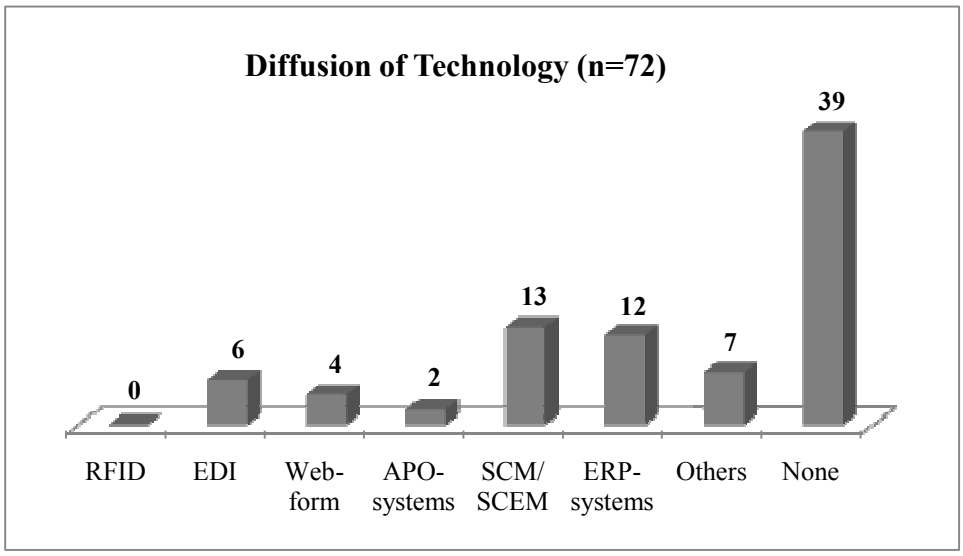

Figure 3: Diffusion of Technology (absolute description, multiple choices possible)

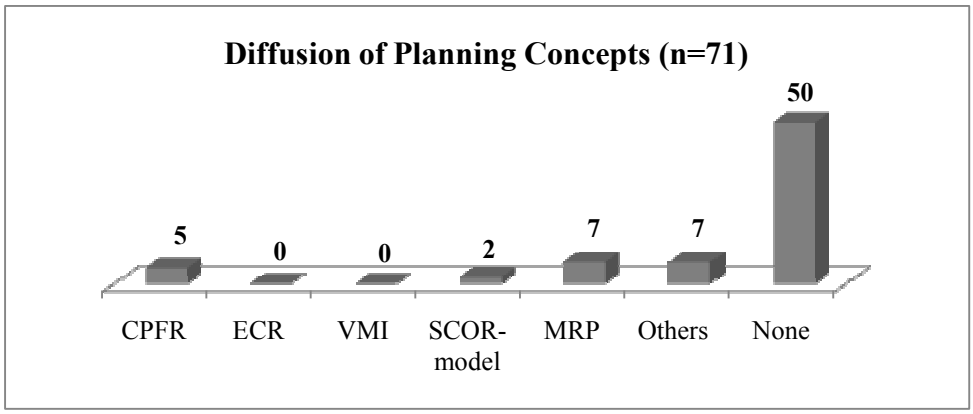

Figure 4: Diffusion of Planning Concepts (absolute description, multiple choices possible)

The predominant assumption that the use of technologies and planning concepts for IS-support along the supply chain depends on the size of the enterprise leads us to further analysis. The concentration on the size and the IS alone does not allow definite explications. The results differ depending on the differentiator that is used to identify company size (number of employees or turnover). Although no general statement can be concluded, the results show that, concerning technologies and headcount, APO is only used by large companies, whereas EDI and web forms are implemented by small-sized enterprises. Surprisingly the results differ when using the turnover as differentiator: then EDI and the web forms seem to be implemented by small and large companies. On the contrary, APO-systems are only used by big companies, independently from the differentiator. Regarding the turnover SCM and ERP-systems are used more often by large enterprises, but when considering

the number of employees, the allocation is more or less balanced. These two technologies seem to be less dependent from the company-size. With reference to the planning concepts the results reveal that CPFR is predominantly implemented by mid-sized enterprises, while SCOR solely is used by medium ones.

Therefore it can be stated that, from a scientific point of view, even the most common technologies are adopted rarely by the small- and mid-sized enterprises in this sector – not to mention more complex and new technologies. Thus it is a great challenge to find appropriate solutions and implementations to support the sustainable production with renewable resources.

Question 4: What is the impact of IS and/or concepts on the uncertainty in planning and usage of renewable resources?

The first main insight from the study is that the implementation of technologies does not go along with reduced uncertainties as it would be stated typically regarding IS as an uncertainty reducer or the value of information for reduced uncertainty (Rowe 1994). To our surprise those companies using ERP-systems perceive more uncertainties than the companies without ERP-systems. If fewer technologies are implemented, less uncertainty occurs (see Table 3).

Technologies crossed with Uncertainty Perception					
			Uncertainty Perception		Total
			Yes	No	
	SCM / SCEM	Number	5	8	13
		% inside of Uncertainty Perception	23.8 % (18.6 %*)	15.7 % (14.3 %*)	
		% from total	6.9%	11.1%	18.1 %
	ERP-systems	Number	8	4	12
		% inside of Uncertainty Perception	38.1 % (29.6 %*)	7.8 % (7.1 %*)	
		% from total	11.1%	5.6 %	16.7 %
	None	Number	8	31	39
		% inside of Uncertainty Perception	38.1 % (29.6 %*)	60.8 % (55.4 %*)	
		% from total	11.1%	43.1 %	54.2 %
Total		Number	21	51	72
		% from total	29.2%	70.8 %	100.0 %
* Percentages in parentheses are column-wise relativized to 100 %					

Table 3. Abridgement of Cross-Tabulation "Technologies crossed with Uncertainty Perception"

What can be assumed here is that there is no interdependency between the perception of uncertainty and the implementation of technologies. One possible explanation could be that IS and supporting technologies serve as an enabler of more information und reveal hidden problems. Once they are implemented the uncertainties come to light. If uncertainties are seen as plan variance the data gathered by IS can help to identify these variances whereas they are not observed without IS. On the other hand it seems possible that fixed long-range plans, determined for instance by MRP-Systems, are especially vulnerable to uncertainties. This problem is known in the scientific literature as system nervousness (Ho, 1989; Koh and Saad, 2004). Similar results are derived by Koh and Simpson for ERP-systems in small- and mid-sized enterprises (2005). Although ERP-systems create a competitive advantage, they do not decrease uncertainty. It seems possible that ERP-systems were introduced because of the existing uncertainty – which means that they are intended to manage the existing uncertainty.

The same is true for SCM: 38.5 % of the companies using this general concept perceive uncertainties, 61.5 % do not. This rate is relatively high against the background that SCM is typically used to reduce uncertainty and achieve planning stability (Childerhouse and Towill, 2004; Van der Vorst, Beulens, De Wit and Van Beek, 1998).

No further analysis can be conducted concerning the planning concepts, because the number of companies which use concepts is too small. Therefore no representativeness is given.

To resume the results in order to research question 4, it has to be said that neither technologies nor planning concepts for IS-support along the supply chain are used frequently. With regard to the qualitative interviews it can be found that the implementation of IS is not considered necessary. The companies know how to deal with quality irregularities or supply shortfalls and have developed a routine of how to treat uncertainties when using renewable resources. One interview member pointed out that people working with such resources are somewhat different and more "down-to-earth" than others and

therefore they would not be interested in IS, even if the company was bigger. In contrast to that our quantitative results have shown that there is a dependency on the company size. This particularly affects the technologies APO, SCM and ERP-systems and planning concepts like CPFR and SCOR-model.

By and large it must be stressed that the implementation of IS along the supply chain does not guarantee a decrease of the perception of uncertainty. Obviously IS serves as enabler for better information and thus helps to identify uncertainties. The impact on reducing it should be examined in further studies.

CONCLUSION

In this paper we presented a quantitative study amongst 75 companies which use renewable resources as an input for production. Four participants for qualitative interviews were extracted. This approach might help the researcher to understand the practice by trial and error in different studies (Cavaye, 1996). First insights from the broad study were supplemented and consolidated with the deeper insights from the interviews. The key issues of our research were the structure of the companies, the use of IS and supporting methods and the underlying uncertainty.

Results and Limitations

Many of the companies are, dependent on the differentiator, small or mid-sized enterprises. The Supply Chain of renewable resources is relatively short. Although most companies are comparatively small, their import area is large. Most of them obtain their renewable resources internationally. The case studies have established that this sourcing strategy is chosen because of quality aspects and better processing of the raw materials in other countries. Other possible reasons for the companies could be the distribution of the uncertainties or simply the lack of other sources. Sophisticated solutions and technologies to manage the supply chain are mainly used by large enterprises. The smaller ones either do not have the capacity to operate such a system or they do not see the necessity to do so. The same tendency can be observed regarding the planning concepts. Their spreading among the sample is even less.

The study presented above bases on a sample that was taken only from companies located in German-speaking countries. Therefore it cannot safely be said that the results and conclusions drawn from this sample are true for other countries as well. Additionally, the sample contains mainly small companies. Since large companies have different business processes, their perspective on the topic could differ. Another limitation is that the ranges of the import areas of the surveyed companies are known, but the structure is unclear. Raw materials could mainly be procured from the surrounding area, but if there is only one international supplier, the whole supply chain looks a lot more international and complex. The acceptance of IS, the associated factors for the adoption and reasons for and against IS implementation are not surveyed, apart from some basic insights from the case studies.

Implications for future research

Taking these results into consideration, it can be noticed that there is a potential for intensified use of IS, managing the supply chains of small enterprises, which process renewable resources. Although they are small, they often have worldwide suppliers, so their supply chain underlies different uncertainties. Thereby it has to be taken into account that those companies usually do not have much manpower. So the offered solutions would have to be easy to use and reasonably priced. To fulfill these requirements, the software does not need to facilitate full complexity. Future research could be conducted to find out if small companies have interest in managing their supply risks with the help of IS. If those companies could profit from this and are willing to use it, the next research topic would be an appropriate software design. If there are planning concepts that could fit the requirements of the discussed companies, further work would have to be done to find out how they could look like. Maybe no new concepts are necessary, but the established ones are seen as “too big” for the small companies. If that were the case the research work would have to reconsider how the special interests of small companies could be implemented. It remains unclear whether the results can be generalized, which could be another research topic. The special requirements in this industry sector should be kept in mind when doing future research in the area of Green through IS.

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