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From Knowledge to Application

Dissemination of sustainability management tools in large German companies

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ABSTRACT

The operationalisation of sustainability on the corporate level is recognised to be a management task and implies the choice and application of management tools. Although researchers have proposed a large number of sustainability management tools in literature, little is known about their acceptance and diffusion. This paper discusses which sustainability management tools are known and applied in practice and conducts a longitudinal analysis based on three empirical surveys among large German companies carried out in 2002, 2006 and 2010. One important result is that the knowledge and the application of sustainability management tools are positively related. Furthermore, the application of sustainability management tools has increased throughout the period of the surveys. A main conclusion drawn from the empirical results is that increased knowledge, e.g. through the promotion of approaches and related professional education, may be a driver of more frequent application of sustainability management tools and thus foster sustainable development.

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1. INTRODUCTION

For the last two decades sustainability management has received increasing attention in management literature and in corporate practice. This is for example expressed in a worldwide growing number of companies addressing sustainability (Dunphy et al., 2007). The implementation of corporate sustainability is considered to be an important management task (Shrivastava, 1995; Epstein, 2008) with the aim of integrating social and environmental issues into business management practices in the company (see also Shrivastava and Hart, 1995). This integration does not only require a strategic approach to sustainability but also the successful application of concrete measures (similar to Volberda et al., 2001; WBCSD, 2002; Boiral, 2006). This implies various decisions such as the assignment of responsibilities in the organization, the design of planning and control processes and the choice and application of strategic and operational management tools. Furthermore, Boiral (2002) notes that the implementation of corporate sustainability requires the acquisition of new knowledge as well as the handling of new practices. In response to this, various researchers have proposed a large number of sustainability management tools (see e.g. European Commission, 2004; Tencati et al., 2004; Biebeler et al., 2005; Hahn and Scheermesser, 2006; Epstein, 2008). These tools address different aspects of sustainability, such as environmental issues, social issues or integrative aspects of sustainability linking environmental, social and economic perspectives of management. However, management approaches established in literature may not necessarily always be useful in corporate practice, as for example pointed out by Ackermann and Eden (2011) with regard to the management of stakeholder relations. Similarly, Husted and Allen (2007, 607) call to provide corporate practitioners with “better tools” for corporate social responsibility (CSR) management and assessment.

A closer examination of the literature on sustainability management reveals that management research has until today largely neglected the analysis of the implementation of sustainability management tools in practice and how it has developed over time. Longitudinal studies in environmental and sustainability management have so far rather focused on the development and the determinants of environmental businesses or corporate sustainability in general (e.g. Bansal, 2005; Lee and Rhee, 2007; Holt, 2010), the definition of corporate sustainability and related concepts (e.g. Montiel, 2008), single case studies (e.g. Tregidga and Milne, 2006) or special interest topics like the development of social and environmental reporting (e.g. Gray et al., 1995; Herzig and Godemann, 2010; Kolk, 2010). This is why this paper analyses the knowledge about and the application of sustainability management tools in large companies in Germany. The analysis is based on a longitudinal study covering three points in time: 2002, 2006 and 2010. The development of both knowledge and application of sustainability management approaches is analysed as well as the relationship between knowledge and application and its development over time. The paper also sheds light on whether knowledge may be a driver of the application of sustainability management tools. The findings allow for the deduction of measures which could support further dissemination and application of management tools.

The paper is structured as follows. After an introduction to sustainability management tools and a short description of their role for the realisation of corporate sustainability (Section 2),

Section 3 explains the methodological approach of the longitudinal study. Section 4 presents and analyses the empirical results which are discussed in the concluding Section 5.

2. TOOLS FOR SUSTAINABILITY MANAGEMENT

The implementation of corporate strategies and operational goals requires the support of management tools. Tools exist in the form of concepts, systems and instruments. The choice and application of these management tools is without doubt a core task for business managers. It is thus not astonishing that management literature and practitioner-orientated management books suggest a wide range of different approaches (e.g. Rigby and Bilodeau, 2007; Nagel et al., 2010).

This is similar with the sustainability management literature even though the number of publications is relatively low compared to conventional management publications. Relevant work has been published by Epstein (2008) discussing the concept of corporate sustainability and related tools, as well as by Tencati et al. (2004) and the European Commission (2004) who analyse CSR standards, initiatives and instruments. Biebeler et al. (2005) discuss the characteristics of several such instruments with the help of case studies. Furthermore BMU and BDI (2002) compile and Hahn and Scheermesser (2006) analyse different environmental and social management tools in the context of German companies. Sustainability related activities in an SME context have been dealt with by Bos-Brouwers (2010). Additionally, several practical introductions can be found, e.g. by Thompson (2002) on environmental management tools.

The multitude of publications reveals that tools of sustainability management have been proposed for all corporate functions and include environmental, social and integrated sustainability management approaches. They can be differentiated into more quantitatively orientated, ‘hard’ approaches (such as environmental accounting, indicators, etc.) and more qualitative, ‘soft’ approaches (such as employee volunteering, sustainability quality circles, etc.). Prevalent (environmental, social or sustainability) tools address:

- physically tangible issues such as material and energy flows (e.g. Jasch, 2009; von Weizsäcker et al., 2009);
- performance measurement and management such as life cycle assessment (LCA), sustainability indicators, sustainability balanced scorecard, benchmarking, etc. (e.g. Schaltegger and Burritt, 2000; Springett, 2003; Gray, 2010);
- supply chains (e.g. Carter and Rogers, 2008; Seuring and Müller, 2008);
- innovations such as eco-design, quality circles, etc. (e.g. Foster and Green, 2000; Bos-Brouwers, 2010);
- communication and reporting such as stakeholder dialogues, sustainability report, etc. (e.g. WBCSD, 2002; Ackermann and Eden, 2011);
- management systems such as EMAS, ISO 14001, SA 8000, etc. (e.g. Darnall et al., 2008; Müller et al., 2009);
- organizational learning and adaptation (e.g. Jennings and Seaman, 1994; Hunting and Tilbury, 2006; Dunphy et al., 2007; Müller and Siebenhüner, 2007);
- staff involvement such as training, incentive systems, corporate culture, etc. (e.g. Daily and Huang, 2001).

The extensive literature dealing with the multitude of sustainability management approaches shows that a wide range of sustainability management tools exist and can be tried out,

applied, further developed or established for routine use in a company. It can, however, be expected that companies make a choice and only implement those sustainability management tools which they consider to be practical and (most) beneficial as resources, especially time, personnel and money, are limited. The choice and application of particular sustainability management tools thus reflect companies' priorities with regard to sustainability and constitute implementation patterns of emergent sustainability strategies in practice (for a discussion of strategy patterns see e.g. Mintzberg, 1978, Mintzberg et al., 1998).

However, referring to contingency theory (e.g. Woodward, 1981; Lawrence and Lorsch, 1967) the choice of sustainability management tools may not be based on full information and the application in corporate practice may thus be bounded rational (March and Simon, 1958). Contingencies may include a lack of information on which tools of sustainability management exist and how useful they are. Thus one reason why some tools are not applied may be that they are not known. This is why several research questions have to be addressed to comprehensively analyse the implementation of sustainability management tools in practice.

3. RESEARCH QUESTIONS AND METHODOLOGICAL APPROACH

Dealing with the implementation of sustainability tools in corporate practice this paper investigates the following questions:

- Which tools of corporate sustainability management are known and which are applied in large German companies?
- How have the knowledge and application of sustainability management tools developed over time?
- What is the relationship between the application of sustainability management tools and the companies' knowledge of these tools?
- How has the relationship developed over time?

The research questions will be answered through a longitudinal study comprising three surveys which were carried out among large German companies in 2002, 2006 and 2010. The longitudinal analysis includes the following steps:

- The *knowledge* and *application* of sustainability management tools in each survey (Section 4.1) and the *development* of knowledge and application over time (Section 4.2) indicate whether operational knowledge in corporate sustainability management is increasing and whether tools are being increasingly accepted.
- The *difference between knowledge and application* (knowledge-application gap), the *relative application* of sustainability management tools (application in relation to knowledge) (Section 4.1) and the *development* of these two indicators over time (Section 4.2) demonstrate the (perceived) practicality of existing tools of sustainability management. Furthermore they show how fast the knowledge of sustainability management approaches is transferred into action, i.e. the application of the tools.
- Furthermore, the discussion of *knowledge as a possible driver of application* comprises the analyses of four categories of tools (Section 4.3). Firstly, knowledge can only be interpreted as a driver if the application increases with the knowledge. A first possible measure of whether knowledge precedes application is thus to investigate whether the application of *increasingly known tools* also increases over time. A second measure will be the development of the application of tools which have *already been well-known* for a while. As the transformation of knowledge into application needs time, the difference between knowledge and application cannot be eliminated at once but it should get smaller over time for these tools – for which no (substantial) knowledge increase over time can be expected. Thirdly and fourthly, to complete this analysis, the development of the application of tools which are *decreasingly known* over time or *have been less well-known* in all three surveys is discussed. If knowledge is a driver their application should not increase as clearly as the application of more well-known tools or could even decrease.

Sample

In every of the three survey years the 120 largest German companies by sales (according to major German newspapers Frankfurter Allgemeine Zeitung, 2002, 2006; Welt online, 2009, adjusted for subsidiary companies) were asked to fill in a questionnaire. The sustainability managers or other persons in charge of sustainability issues were contacted by phone and asked to fill in the questionnaire sent to them by e-mail or mail, where necessary involving those in the company who could support them. The respondents were mostly sustainability, EHS-, CSR- or sustainability managers or, to a lower extent, associated with public relations or communications. Further sample characteristics can be found in Table 1. The database, due to the high albeit decreasing response rate, is sufficient for statistical analyses. The data were analysed with PASW Statistics 18.

Table 1: Characteristics of the survey samples (2002, 2006 and 2010)

Sample characteristics	**2002**	**2006**	**2010**
sample size (response rate)	44 (36.7%)	42 (35.0%)	31 (25.8%)
Average sales (in million Euro)*	20,629	21,173	24,701
Average number of employees*	86,207	82,090	88,651
Number of sustainability tools queried	52	78	79

*based on Frankfurter Allgemeine Zeitung, 2006, 2006; Welt online, 2009.

The longitudinal study focuses on large German companies for three reasons: firstly, large companies are publicly exposed which may drive them to engage with sustainability more strongly than small and medium-sized enterprises. Secondly, they can be expected to have the resources to try out and implement sustainability tools on a large scale (Esrock and Leichty, 1998; Marsden, 2000). Thirdly, the narrow focus on Germany eliminates decisive influences related to contingencies, e.g. in case that some corporate sustainability management activities or tools may be regulated or promoted more in one country than in another.

Content of the survey

The basic requirement for a certain tool of sustainability management to be applied in corporate practice is that it is known. This is why the respondents representing the 120 largest companies in Germany were firstly asked which sustainability management approaches they know. This was done on the basis of a list of tools provided in the questionnaires and drawn from a review of contemporary sustainability management literature (Section 2). The paper thus follows a deductive approach to explore the knowledge and application of the relevant ‘pool’ of sustainability management tools. To capture the contemporarily relevant pool of tools, the range of tools considered in the questionnaires was extended by newly developed, primarily integrative tools (such as sustainability management

system or sustainability accounting) leading to an increase in number of tools from 52 to 79 between the three surveys (see Table 1 and Table A in the Appendix for an overview of the queried tools). The managers also had the option to add tools which were not listed.
Secondly, the managers were asked which of the known tools are at least partially applied in their company to support corporate sustainable development. The results of the surveys will be presented and discussed in the following.

4. EMPIRICAL RESULTS AND ANALYSIS

This Section presents the findings on the knowledge and application of sustainability management tools using longitudinal data gathered at three points in time, in 2002, 2006 and 2010. The findings are presented in three steps. The next Section shows how knowledge is related to the application of sustainability management tools, distinguishing between absolute and relative application. Secondly, the dynamics in the application of tools are presented. Again, this analysis is carried out for the absolute and relative application. Thirdly and finally, an in-depth analysis is conducted of whether knowledge can be a driver for the application of sustainability management tools.

4.1 Knowledge and application of sustainability management tools

More knowledge relates to more frequent application

Figures 1, 2 and 3 provide an overview of the percentage of companies which i) know and ii) (know and) apply a certain sustainability management tool in 2002, 2006 and 2010. The difference between knowledge and application (i.e. the knowledge-application gap) is shown by the area between the two curves. The tools are ordered according to their degree of knowledge among managers: on left the least known, on right the most known tools.

A first observation is that all kinds of combination of knowledge and application rates exist: some tools like quality management systems which include environmental and social issues have been known by almost all companies (between 95.2% and 100.0%) and frequently applied (between 92.9% and 95.5%) in all three surveys. Other well-known tools such as eco labels (known by 61.3% to 95.5%, applied by 28.6% to 41.9%) are, however, not applied as often. This means that the difference between knowledge and application is relatively large. In contrast, some less well-known tools such as early detection (known by 42.9% to 61.3%, applied by 31.0% to 41.9%) are applied relatively often in comparison to their degree of knowledge, i.e. the difference between knowledge and application is comparatively small. A last group of tools is neither well-known nor often applied such as eco-compass (known by 25.8% to 34.1%, applied by 0.0% to 2.4%).

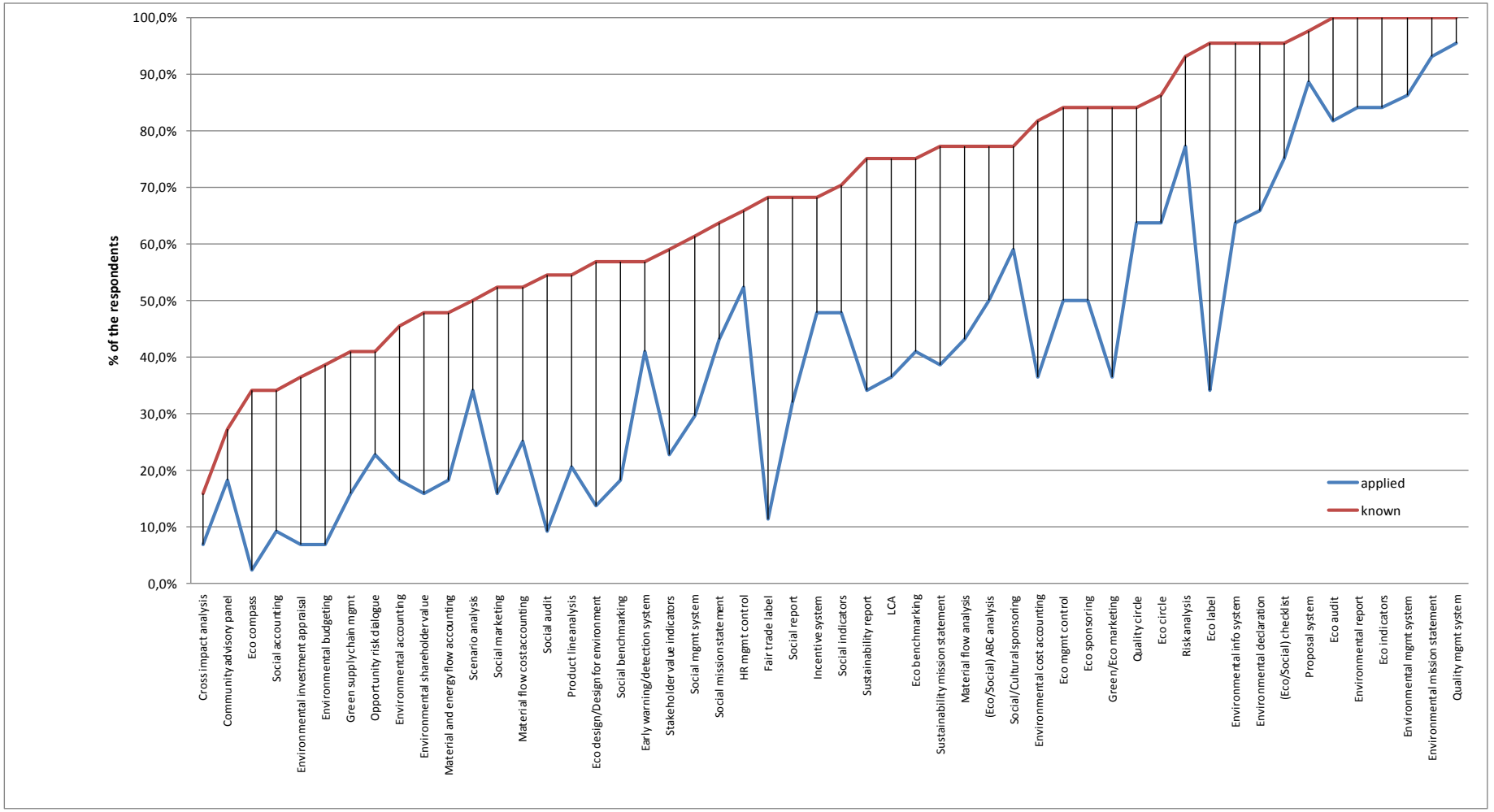

Figure 1: Knowledge and application of sustainability management tools in 2002

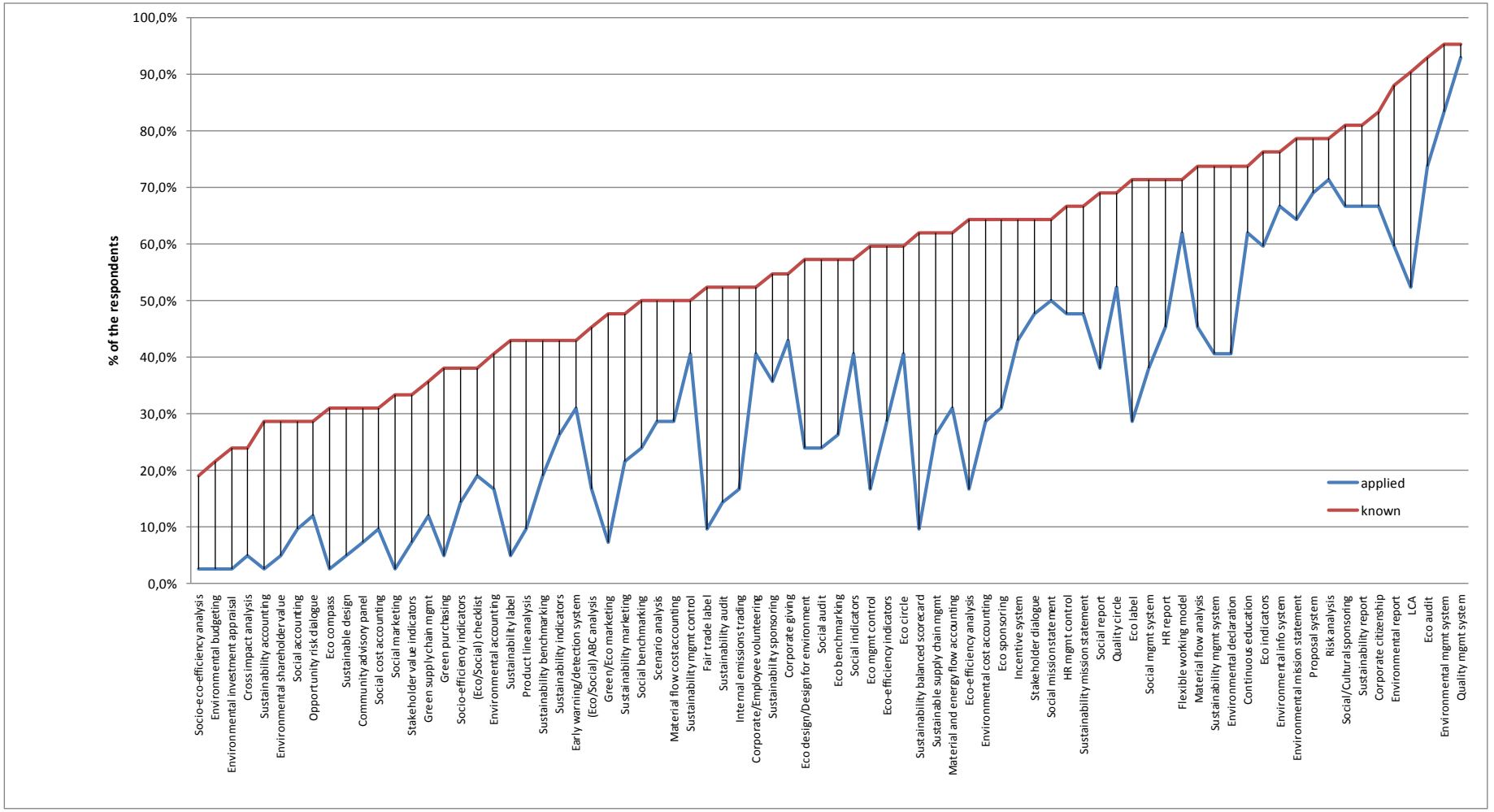

Figure 2: Knowledge and application of sustainability management tools in 2006

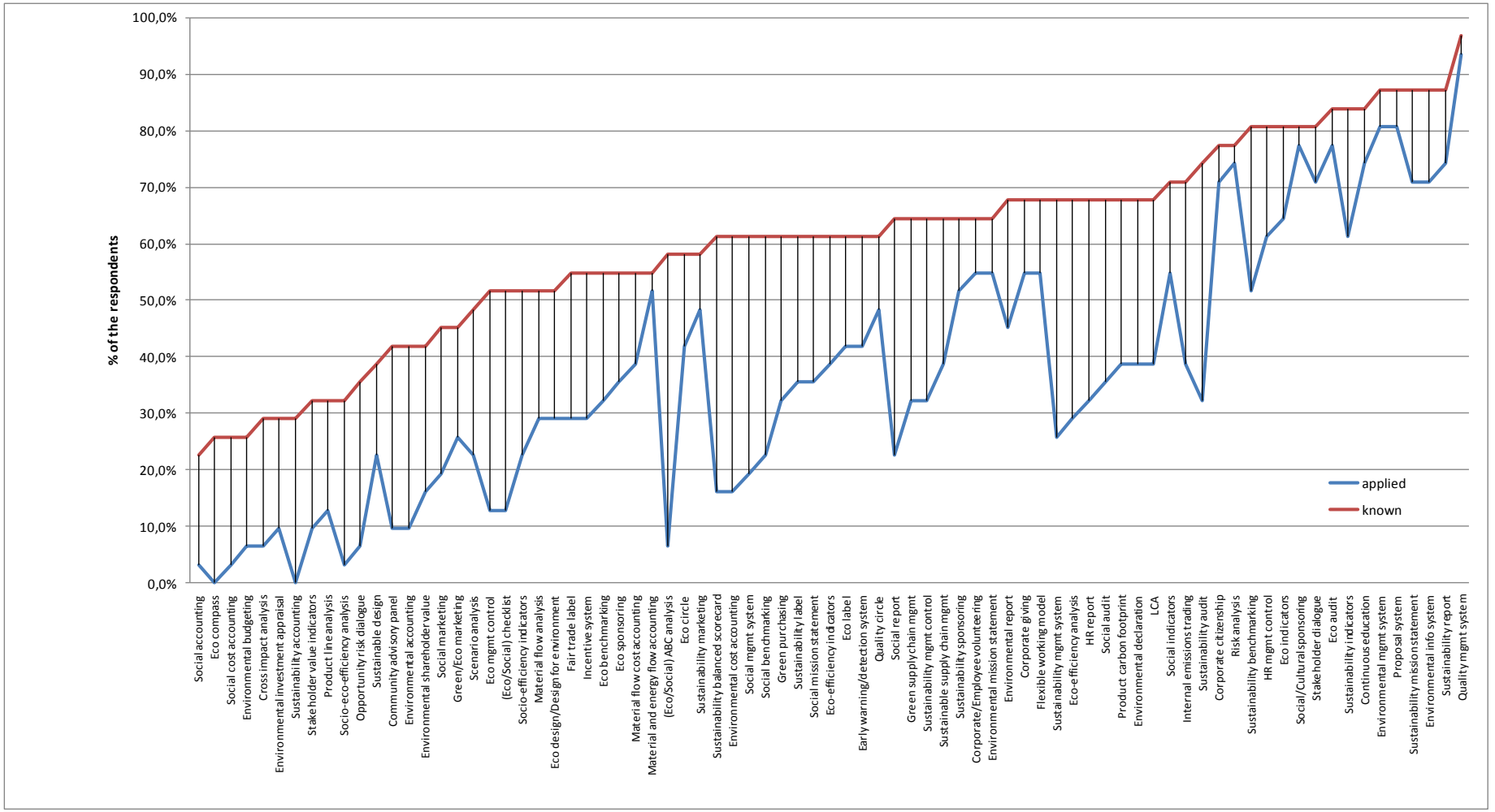

Figure 3: Knowledge and application of sustainability management tools in 2010

The general relationship between knowledge and application of sustainability management tools is nevertheless characterized by a very strong positive correlation on highly significant levels. Table 2 offers further details on the knowledge and application of sustainability management tools and their relationship (when comparing the data of 2002, 2006 and 2010 it has to be considered that the number of tools which were queried varies over time).

Table 2: Knowledge and application of sustainability management tools

Knowledge and application of sustainability management tools	**2002 (52 tools)**	**2006 (78 tools)**	**2010 (79 tools)**
Average knowledge	68.8%	56.2%	60.1%
Average application	41.1%	31.8%	36.9%
Average knowledge-application gap	27.8%	24.4%	23.2%
Average ratio application/knowledge	54,8%	50,1%	55,8%
Correlation of knowledge with application (Pearson)	0.88**	0.89**	0.89**

**p < 0.01

The positive relationship between knowledge and application indicates that approaches which are known more are absolutely applied more often in corporate practice. The relative application is to be further examined next.

More knowledge relates to more relative application

In order to further examine the *difference between knowledge and application (i.e. the knowledge-application gap)* on one hand and the *relative application (application in relation to knowledge) on the other hand,* the sustainability management tools are divided into three categories:

- well-known tools: known by more than 66% of the respondents (e.g. sustainability reporting or environmental management systems);
- moderately known tools: known by more than 33% but not more than 66% (e.g. environmental accounting or social marketing);
- less well-known tools: known by not more than 33% (e.g. cross impact analysis).

Table 3 displays the knowledge-application gaps and the ratio between application and knowledge for *well-known* tools, *moderately known* tools and *less well-known* tools for the years 2002, 2006 and 2010. The table shows that the absolute number of well-known tools has been rather constant in all three years, whereas the relative number has decreased due to the increased number of relevant tools. The majority of tools were moderately known in 2006 and 2010.

Table 3: Application of well-known, moderately and less well-known tools

	Tools*	No. of tools (%)	Average knowledge-application gap	Variance of knowledge-application gap	Average application/ knowledge	Variance of application/ knowledge
2002 (52 tools)	Well-known	29 (55.8%)	28.1%	2.0	65.6%	3.7
	Moderately known	21 (40.4%)	29.0%	0.8	39.9%	3.9
	Less well-known	2 (3.8%)	9.1%	0.0	54.8%	2.8
2006 (78 tools)	Well-known	25 (32.1%)	20.3%	1.1	73.3%	2.2
	Moderately known	41 (52.6%)	27.6%	1.1	44.9%	4.4
	Less well-known	12 (15.4%)	21.8%	0.2	19.2%	1.2
2010 (79 tools)	Well-known	29 (36.7%)	19.4%	1.5	73.5%	3.3
	Moderately known	40 (50.6%)	26.0%	1.2	52.2%	4.3
	Less well-known	10 (12.7%)	22.9%	0.1	18.7%	1.9

*well-known: $x > 66\%$, moderately known: by $33\% < x \leq 66\%$, less well-known: $x \leq 33\%$

The comparative analysis shows that the average knowledge-application gap is smaller for tools that are well-known than for less well-known and especially for moderately known tools in 2006 and 2010. For 2002, when only 52 tools were queried, this relationship is not that clear, but it has to be considered that the category of less well-known tools only contains two tools in 2002 so that these particular figures are not conclusive.

Thus, examining 2006 and 2010 the average ratio between application and knowledge is higher the more the tools are known (the numbers for less well-known tools in 2002 are not considered in this context.) These results imply a positive relationship of knowledge and the ratio between application and knowledge, which is emphasized by their significant correlation: in 2002 the correlation of knowledge with the ratio between application and knowledge was 0.67 and in 2006 and 2010 it was 0.77 (on a significance level of 0.01). Thus, well-known tools are not only applied more often in absolute terms (application) but also in relative terms (application in relationship to knowledge).

These facts imply that the perceived practicality of these tools is high. Furthermore, the results may indicate a causal relationship between knowledge and application. Generally, the relationship

between knowledge and application may exert effects in two directions. Firstly, knowledge is a required first step preceding the application of a tool. However, the direction may also be the other way round: once a tool has been introduced and applied in a company other companies may learn about the existence of the approach, especially if there is uncertainty about how to deal with the issues addressed by the approach (see DiMaggio and Powell, 1983 for a discussion of mimetic and, more generally, institutional isomorphism). With some exceptions this second situation may be of little relevance in the context of this paper as the respondents to the questionnaire were those in charge of the sustainability management of their companies. These people are by profession well informed about sustainability management tools and are usually the key actors of sustainability implementation.

4.2 Dynamics in the application of sustainability management tools

In the following a longitudinal analysis is carried out to analyse the development of knowledge and application of sustainability management tools over time. Furthermore, to analyse whether knowledge may be a driver of application, four categories of tools are analysed: increasingly and already well-known as well as decreasingly and less well-known tools.

Increasing application over time

When comparing the results of the three surveys over time it becomes apparent that the average knowledge and the average application have increased between 2006 and 2010, when a similar number of tools were queried (see Table 2). This relationship cannot be confirmed when the 2006 data is compared with the data from 2002. However, it has to be considered that in 2002 fewer tools were included in the questionnaire. In order to compare the difference of knowledge and application and the relative application of tools over time in more detail, firstly the knowledge-application gap and secondly the ratio between application and knowledge are analysed in the following. The development of these two indicators shows whether the knowledge of sustainability management approaches is transferred into action, i.e. the application of tools. This analysis may thus reflect the (perceived) practicality of sustainability management tools.

Increasing relative application over time

The gap between knowing and applying a sustainability management tool is shown by the striped area in Figures 1, 2 and 3 for the surveys of 2002, 2006 and 2010. A comparison of the knowledge-application gap shows that the average gap between knowledge and application has decreased between the surveys, particularly between 2002 and 2006, but also between 2006 and 2010 (see Table 2). Also, the size of the largest gap has been decreasing: whereas the largest gap was 61.4% in 2002, it went down to 52.4% in 2006 and to 51.4% in 2010. This is particularly true for well-known tools (known by more than 66% of the respondents in all three surveys): their average knowledge-application gap strongly decreased (see Table 3).

This means that, on average, known sustainability management approaches are nowadays applied more often than they were in the past. Especially the well-known tools of sustainability management have apparently proven to be beneficial in corporate practice and, because of this

(perceived) high practicality, are applied more often. Methodical knowledge is transferred to a larger extent into action.

This observation is also supported by the development of the ratio between application and knowledge of sustainability management tools. Figure 4 clearly shows that the relative application (ratio of application and knowledge) of sustainability management tools has increased between 2006 and 2010. However, the curve is even higher for 2002, but fewer methods were queried then. Table 2 also shows that the average ratio between application and knowledge was higher in 2010 than in 2002 – although the absolute number of relevant tools increased throughout this time. This demonstrates that the application of sustainability management tools has increased even in relative terms and may attest enhanced innovation and organisational learning in the context of sustainability.

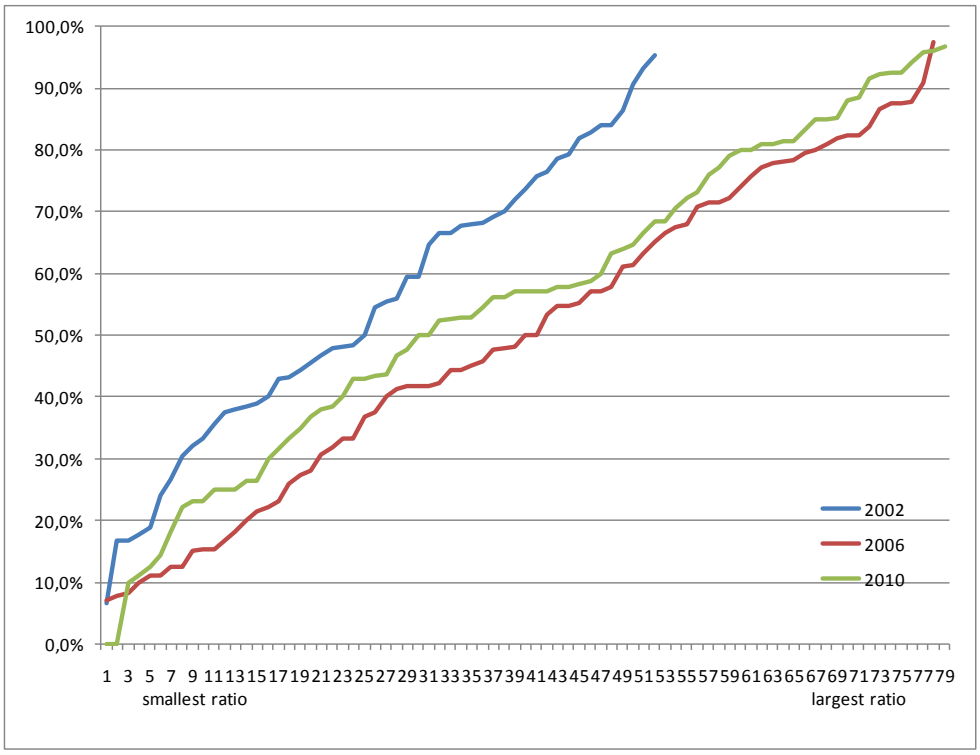

Figure 4: Ratio between application and knowledge of sustainability management tools in 2002, 2006, 2010 (ordered according to size of ratio: left smallest, right largest ratio)

To analyse whether knowledge may be a driver of application, a more in-depth analysis of the relationship between knowledge and application of sustainability management tools was carried out.

4.3 Knowledge as a driver of application

In the following, four categories of tools will be analysed in more detail in order to discuss whether knowledge may be a driver of application. The comparison of the results of these four analyses is

carried out using the indicators ‘application’, ‘knowledge-application gap’ and ‘ratio between application and knowledge of tools’.

Increasingly known tools

Increasingly known tools show a positive knowledge increase between two points in time. In total, 26 tools were increasingly well-known in the period between 2006 and 2010 (see Table B in the Appendix). Most sustainability management approaches with increasing knowledge are fairly new tools with an integrated sustainability orientation (e.g. sustainability report, sustainability indicators, etc.) as opposed to those with environmental or social foci only. As these integrative approaches were considered in the survey in 2006 for the first time (with the exception of sustainability reporting) the analysis can only be made for the surveys of 2006 and 2010.

The analysis reveals that with increasing knowledge the application of these tools has increased, too (see also Table B). The average knowledge grew from 49.0% in 2006 to 63.8% in 2010 and the average application grew from 25.1% in 2006 to 40.2% in 2010. This is an average increase of 14.8% in knowledge which went along with an average increase of 15.1% in application. The increase in knowledge and the increase in application are positively related: they show a correlation of 0.72 (on a significance level of 0.01).

The average knowledge-application gap of these tools, however, has only slightly decreased by 0.3% from 23.9% to 23.6%. That is because the knowledge-application gaps of these tools have developed differently: some have decreased whereas others have increased. On the contrary, the average ratio between application and knowledge has clearly grown by 12.6% from 45.3% in 2006 to 57.9% in 2010.

Already well-known tools

A second measure to investigate whether knowledge may be a driver of application is the development of the application of approaches which have already been well-known for a while (known by more than 66% of the respondents in all three surveys). Table C in the Appendix shows the results of the analysis of these thirteen tools. Whereas the application of these tools has developed differently, the knowledge-application gaps have decreased between 2002 and 2010 for all but one of these tools. The average gap has also decreased by 9.2% (from 22.4% in 2002 to 17.2% in 2006 and 13.2% in 2010).

Analogously, the ratio between application and knowledge has increased for all but one of the approaches. The average ratio has increased by 8.7% (from 74.0% in 2002 to 78.9% in 2006 to 82.7% in 2010). This displays that the majority of already well-known or ‘established’ approaches has been increasingly applied which supports the proposition introduced earlier that it takes some time until (suitable) knowledge is transferred into application (time lag) and the gap ‘closes’.

Decreasingly known tools

Another analysis is based on tools with continuously decreasing knowledge between 2002, 2006 and 2010. A list of these 20 tools can be found in Table D in the appendix. Possible explanations for the decrease of knowledge may include the emergence of new sustainability management tools replacing earlier developed tools (e.g. sustainability report replacing environmental report) or the

unsuccessful application of older tools which are not communicated anymore in professional education and company-internal training.

The analysis shows that for all but one tool the application has decreased together with the decrease in knowledge between 2002 and 2010 (with an average decrease of 23.7% in knowledge and of 15.0% in application). The knowledge-application gaps of these tools have, however, developed differently: whereas for several tools the difference between application and knowledge has decreased, it has also increased in some cases, resulting in an average decrease of 8.8%. Likewise, the ratio between application and knowledge has developed inconsistently with a slight average decrease of 2.2%.

Less well-known tools

Finally, those tools were analysed which are less well-known in corporate practice, meaning they have been known by less than 50.0% of the respondents in all three surveys (only those tools queried in all three surveys were included). Those 9 tools belonging to this category are listed in Table E in the Appendix. The majority of these tools have not only experienced a decrease in knowledge (with a slight average decrease of 3.0% between 2002 and 2010) but also in application (with an average decrease of 4.3%). Furthermore, the average knowledge-application gaps of these tools have slightly increased by 1.4% whereas the average ratio between application and knowledge has decreased by 12.3%.

Although the number of cases analysed here is relatively small and individual tools have developed differently, the overall results indicate that with less knowledge the application of sustainability management tools also decreases. This, again, supports the proposition that knowledge may be a driver of application.

5. DISCUSSION AND CONCLUSIONS

Sustainable development of companies does not only require the formulation of sustainability strategies but also the successful implementation of concrete measures, such as the application of sustainability management tools (similar to Volberda et al., 2001; WBCSD, 2002; Boiral, 2006). Whilst there is an extent body of literature on sustainability management approaches, little is known about the application and dissemination of the various tools. This paper conducted a longitudinal analysis based on data from three surveys to investigate which sustainability management tools are known and applied in large German companies and how the relationship of knowledge and application has developed since 2002.

The analysis shows that both the average knowledge and the average application of management tools have increased between 2006 and 2010. This relationship is not confirmed for the survey in 2002, but it has to be kept in mind that the number of tools queried was much smaller in 2002. Nonetheless, the relative application, that is the application in relation to the knowledge of a tool, is positively correlated with knowledge and has continuously increased throughout the surveys – although a large number of new, integrative approaches were introduced over time. This result indicates a learning effect and that the integration of sustainability is progressing in corporate practice.

Overall, the analysis of various categories of tools confirms the positive correlation of knowledge with application to be valid not only for the aggregated data but also for various parts of them. Table 4 gives an overview of these results.

Table 4: Results of the analysis of various categories of tools

	Results		
Longitudinal analysis of...	**Application**	**Knowledge-application gap**	**Application/ knowledge**
increasingly known tools	increased	differently, decreased slightly on average	increased
already well-known tools	differently	decreased	increased
decreasingly well-known tools	decreased	differently, decreased on average	differently, decreased slightly on average
less well-known tools	decreased	differently, increased slightly on average	differently, decreased on average

The analyses of various categories of tools show that tools which are increasingly well-known over time are applied more often today than in the past. Their application has not only increased in absolute but also in relative terms. The perceived practicality of these tools can thus be considered high. It will be interesting to observe whether these tools will become even more popular in the years to come.

Furthermore, those tools which have been well-known in all of the three surveys show an increase in their relative application. This result indicates that a time lag exists between knowledge and

application and that this gap is slowly closing for these tools, which supposedly are considered highly practical. It can be expected that these tools will further disseminate among companies in the future.

Crosschecking these results with those tools that are decreasingly known or have been less-known in all three surveys confirms the positive relationship between knowledge and application. Similarly to their knowledge, the application of these tools is low or decreasing over time.

The findings on the dynamics in the relationship between knowledge and application of sustainability management tools may help enhancing the operationalisation of sustainability management. The study is based on a unique set of data collected over a period of eight years which reflects a relevant period for the development of sustainability management characterised by significant developments in different areas of sustainability management such as the emergence of sustainability reporting and accounting. However, additional analyses in the years to come may provide further insights into the development of corporate sustainability management. Additionally, it has to be considered that the survey results, like all survey results, may be subject to social desirability (Fernandes and Randall, 1992). To minimize this effect, the data were collected in an anonymised way.

Notwithstanding these limitations and although the data do not allow substantiated final statements about causality, the analysed measures indicate that knowledge is not only a lead indicator but possibly even a driver of application. Increasingly known approaches are applied more often and it was shown that tools with less or decreasing knowledge are less applied or show a very inconsistent development of application. This may imply that the perceived practicality of these tools is low and that further methodical development is needed for the management of related issues. Furthermore, this result supports the conclusion that the application of sustainability management tools and contributions of companies to sustainable development may be increased through the promotion of existing and new approaches as well as with other related activities (e.g. professional education).

Further research could analyse additional possible influence factors, such as company size or the time period between when a tool has been proposed in literature and when it was applied in companies. An interesting observation is the time it takes until the knowledge-application gap closes and the ‘speed’ with which this happens: even for established tools the knowledge-application gap does not close at once, but decreases slowly. This indicates that a time lag has to be considered in the transformation of knowledge into action and in applying the known.

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APPENDIX

Tool	2002	2006	2010
(Eco/Social) ABC analysis	x	x	x
(Eco/Social) checklist	x	x	x
Community advisory panel	x	x	x
Continuous education	-	x	x
Corporate citizenship	-	x	x
Corporate giving	-	x	x
Corporate/Employee volunteering	-	x	x
Cross impact analysis	x	x	x
Early detection	x	x	x
Eco audit	x	x	x
Eco benchmarking	x	x	x
Eco budgeting	x	x	x
Eco circle	x	x	x
Eco compass	x	x	x
Eco design/Design for environment	x	x	x
Eco indicators	x	x	x
Eco label	x	x	x
Eco control	x	x	x
Eco sponsoring	x	x	x
Eco-efficiency analysis	-	x	x
Eco-efficiency indicators	-	x	x
Environmental accounting	x	x	x
Environmental cost accounting	x	x	x
Environmental declaration	x	x	x
Environmental info system	x	x	x
Environmental investment appraisal	x	x	x
Environmental management system	x	x	x
Environmental mission statement	x	x	x
Environmental report	x	x	x
Environmental shareholder value	x	x	x
Fair trade label	x	x	x
Flexible working model	-	x	x
Green purchasing	-	x	x
Green supply chain management	x	x	x
Green/Eco marketing	x	x	x
Human resource control	x	x	x
Human resource report	-	x	x
Incentive system	x	x	x
Internal emissions trading	-	x	x
Life Cycle Assessment	x	x	x

Tool (continued)	2002	2006	2010
Material and energy flow accounting	x	x	x
Material flow analysis	x	x	x
Material flow cost accounting	x	x	x
Opportunity risk dialogue	x	x	x
Product carbon footprint	-	-	x
Product line analysis	x	x	x
Proposal system	x	x	x
Quality circle	x	x	x
Quality management system	x	x	x
Risk analysis	x	x	x
Scenario analysis	x	x	x
Social accounting	x	x	x
Social audit	x	x	x
Social benchmarking	x	x	x
Social cost accounting	-	x	x
Social indicators	x	x	x
Social marketing	x	x	x
Social mgmt system	x	x	x
Social mission statement	x	x	x
Social report	x	x	x
Social/Cultural sponsoring	x	x	x
Socio-eco-efficiency analysis	-	x	x
Socio-efficiency indicators	-	x	x
Stakeholder dialogue	-	x	x
Stakeholder value indicators	x	x	x
Sustainability accounting	-	x	x
Sustainability audit	-	x	x
Sustainability balanced scorecard	-	x	x
Sustainability benchmarking	-	x	x
Sustainability indicators	-	x	x
Sustainability label	-	x	x
Sustainability marketing	-	x	x
Sustainability management control	-	x	x
Sustainability management system	-	x	x
Sustainability mission statement	x	x	x
Sustainability report	x	x	x
Sustainability sponsoring	-	x	x
Sustainable design	-	x	x
Sustainable supply chain management	-	x	x
Total	52	78	79

Tab. A: Sustainability Management tools queried in 2002, 2006 and 2010 (alphabetical order)

	2006				2010				between 2006 and 2010			
Tool	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**knowledge increase**	**application increase**	**k-a gap increase**	**applied/known increase***
Sustainability mgmt control	50.0%	40.5%	9.5%	81.0%	64.5%	32.3%	32.3%	50.0%	14.5%	-8.2%	22.7%	-31.0%
Sustainability accounting	28.6%	2.4%	26.2%	8.3%	29.0%	0.0%	29.0%	0.0%	0.5%	-2.4%	2.8%	-8.3%
Socio-eco-efficiency analysis	19.0%	2.4%	16.7%	12.5%	32.3%	3.2%	29.0%	10.0%	13.2%	0.8%	12.4%	-2.5%
Community advisory panel	31.0%	7.1%	23.8%	23.1%	41.9%	9.7%	32.3%	23.1%	11.0%	2.5%	8.4%	0.0%
Cross impact analysis	23.8%	4.8%	19.0%	20.0%	29.0%	6.5%	22.6%	22.2%	5.2%	1.7%	3.5%	2.2%
Corporate giving	54.8%	42.9%	11.9%	78.3%	67.7%	54.8%	12.9%	81.0%	13.0%	12.0%	1.0%	2.7%
Sustainability report	81.0%	66.7%	14.3%	82.4%	87.1%	74.2%	12.9%	85.2%	6.1%	7.5%	-1.4%	2.8%
HR management control	66.7%	47.6%	19.0%	71.4%	80.6%	61.3%	19.4%	76.0%	14.0%	13.7%	0.3%	4.6%
Continuous education	73.8%	61.9%	11.9%	83.9%	83.9%	74.2%	9.7%	88.5%	10.1%	12.3%	-2.2%	4.6%
Socio-efficiency indicators	38.1%	14.3%	23.8%	37.5%	51.6%	22.6%	29.0%	43.8%	13.5%	8.3%	5.2%	6.3%
Corporate/Employee volunteering	52.4%	40.5%	11.9%	77.3%	64.5%	54.8%	9.7%	85.0%	12.1%	14.4%	-2.2%	7.7%
Sustainability mission statement	66.7%	47.6%	19.0%	71.4%	87.1%	71.0%	16.1%	81.5%	20.4%	23.3%	-2.9%	10.1%
Social audit	57.1%	23.8%	33.3%	41.7%	67.7%	35.5%	32.3%	52.4%	10.6%	11.7%	-1.1%	10.7%
Sustainability indicators	42.9%	26.2%	16.7%	61.1%	83.9%	61.3%	22.6%	73.1%	41.0%	35.1%	5.9%	12.0%
Stakeholder dialogue	64.3%	47.6%	16.7%	74.1%	80.6%	71.0%	9.7%	88.0%	16.4%	23.3%	-7.0%	13.9%
Sustainability sponsoring	54.8%	35.7%	19.0%	65.2%	64.5%	51.6%	12.9%	80.0%	9.8%	15.9%	-6.1%	14.8%
Sustainability audit	52.4%	14.3%	38.1%	27.3%	74.2%	32.3%	41.9%	43.5%	21.8%	18.0%	3.8%	16.2%
Green supply chain mgmt	35.7%	11.9%	23.8%	33.3%	64.5%	32.3%	32.3%	50.0%	28.8%	20.4%	8.4%	16.7%
Eco-efficiency analysis	64.3%	16.7%	47.6%	25.9%	67.7%	29.0%	38.7%	42.9%	3.5%	12.4%	-8.9%	16.9%
Sustainable supply chain mgmt	61.9%	26.2%	35.7%	42.3%	64.5%	38.7%	25.8%	60.0%	2.6%	12.5%	-9.9%	17.7%
Sustainability benchmarking	42.9%	19.0%	23.8%	44.4%	80.6%	51.6%	29.0%	64.0%	37.8%	32.6%	5.2%	19.6%
Internal emissions trading	52.4%	16.7%	35.7%	31.8%	71.0%	38.7%	32.3%	54.5%	18.6%	22.0%	-3.5%	22.7%
Sustainability marketing	47.6%	21.4%	26.2%	45.0%	58.1%	48.4%	9.7%	83.3%	10.4%	27.0%	-16.5%	38.3%
Green purchasing	38.1%	4.8%	33.3%	12.5%	61.3%	32.3%	29.0%	52.6%	23.2%	27.5%	-4.3%	40.1%
Sustainable design	31.0%	4.8%	26.2%	15.4%	38.7%	22.6%	16.1%	58.3%	7.8%	17.8%	-10.1%	42.9%
Sustainability label	42.9%	4.8%	38.1%	11.1%	61.3%	35.5%	25.8%	57.9%	18.4%	30.7%	-12.3%	46.8%
Average	49.0%	25.1%	23.9%	45.3%	63.8%	40.2%	23.6%	57.9%	14.8%	15.1%	-0.3%	12.6%

Tab. B: Development of increasingly known tools between 2006 and 2010 (*ordered by ‘applied/known increase’)

	2002				2006				2010				between 2002 and 2010			
Tool	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**knowledge increase**	**application increase**	**k-a gap increase**	**applied/known increase***
Environmental report	100.0%	84.1%	15.9%	84.1%	88.1%	59.5%	28.6%	67.6%	67.7%	45.2%	22.6%	66.7%	-32.3%	-38.9%	6.7%	-17.4%
Environmental declaration	95.5%	65.9%	29.5%	69.0%	73.8%	40.5%	33.3%	54.8%	67.7%	38.7%	29.0%	57.1%	-27.7%	-27.2%	-0.5%	-11.9%
Eco indicators	100.0%	84.1%	15.9%	84.1%	76.2%	59.5%	16.7%	78.1%	80.6%	64.5%	16.1%	80.0%	-19.4%	-19.6%	0.2%	-4.1%
Quality mgmt system	100.0%	95.5%	4.5%	95.5%	95.2%	92.9%	2.4%	97.5%	96.8%	93.5%	3.2%	96.7%	-3.2%	-1.9%	-1.3%	1.2%
Proposal system	97.7%	88.6%	9.1%	90.7%	78.6%	69.0%	9.5%	87.9%	87.1%	80.6%	6.5%	92.6%	-10.6%	-8.0%	-2.6%	1.9%
Environmental mgmt system	100.0%	86.4%	13.6%	86.4%	95.2%	83.3%	11.9%	87.5%	87.1%	80.6%	6.5%	92.6%	-12.9%	-5.7%	-7.2%	6.2%
LCA	75.0%	36.4%	38.6%	48.5%	90.5%	52.4%	38.1%	57.9%	67.7%	38.7%	29.0%	57.1%	-7.3%	2.3%	-9.6%	8.7%
Eco audit	100.0%	81.8%	18.2%	81.8%	92.9%	73.8%	19.0%	79.5%	83.9%	77.4%	6.5%	92.3%	-16.1%	-4.4%	-11.7%	10.5%
Risk analysis	93.2%	77.3%	15.9%	82.9%	78.6%	71.4%	7.1%	90.9%	77.4%	74.2%	3.2%	95.8%	-15.8%	-3.1%	-12.7%	12.9%
Environmental info system	95.5%	63.6%	31.8%	66.7%	76.2%	66.7%	9.5%	87.5%	87.1%	71.0%	16.1%	81.5%	-8.4%	7.3%	-15.7%	14.8%
Social/Cultural sponsoring	77.3%	59.1%	18.2%	76.5%	81.0%	66.7%	14.3%	82.4%	80.6%	77.4%	3.2%	96.0%	3.4%	18.3%	-15.0%	19.5%
Sustainability mission statement	77.3%	38.6%	38.6%	50.0%	66.7%	47.6%	19.0%	71.4%	87.1%	71.0%	16.1%	81.5%	9.8%	32.3%	-22.5%	31.5%
Sustainabilty report	75.0%	34.1%	40.9%	45.5%	81.0%	66.7%	14.3%	82.4%	87.1%	74.2%	12.9%	85.2%	12.1%	40.1%	-28.0%	39.7%
Average	91.3%	68.9%	22.4%	74.0%	82.6%	65.4%	17.2%	78.9%	81.4%	68.2%	13.2%	82.7%	-9.9%	-0.6%	-9.2%	8.7%

Tab. C: Development of already well-known tools (knowledge > 66.0% in 2002, 2006 and 2010) (*ordered by ‘applied/known increase’)

	2002				2006				2010				between 2002 and 2010			
Tool	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**knowledge increase**	**application increase**	**k-a gap increase**	**applied/ known increase***
Eco control	84.1%	50.0%	34.1%	59.5%	59.5%	16.7%	42.9%	28.0%	51.6%	12.9%	38.7%	25.0%	-32.5%	-37.1%	4.6%	-34.5%
Environmental cost accounting	81.8%	36.4%	45.5%	44.4%	64.3%	28.6%	35.7%	44.4%	61.3%	16.1%	45.2%	26.3%	-20s.5%	-20.2%	-0.3%	-18.1%
Environmental report	100.0%	84.1%	15.9%	84.1%	88.1%	59.5%	28.6%	67.6%	67.7%	45.2%	22.6%	66.7%	-32.3%	-38.9%	6.7%	-17.4%
Incentive system	68.2%	47.7%	20.5%	70.0%	64.3%	42.9%	21.4%	66.7%	54.8%	29.0%	25.8%	52.9%	-13.3%	-18.7%	5.4%	-17.1%
Social accounting	34.1%	9.1%	25.0%	26.7%	28.6%	9.5%	19.0%	33.3%	22.6%	3.2%	19.4%	14.3%	-11.5%	-5.9%	-5.6%	-12.4%
Environmental declaration	95.5%	65.9%	29.5%	69.0%	73.8%	40.5%	33.3%	54.8%	67.7%	38.7%	29.0%	57.1%	-27.7%	-27.2%	-0.5%	-11.9%
Stakeholder value indicators	59.1%	22.7%	36.4%	38.5%	33.3%	7.1%	26.2%	21.4%	32.3%	9.7%	22.6%	30.0%	-26.8%	-13.0%	-13.8%	-8.5%
Environmental mission statement	100.0%	93.2%	6.8%	93.2%	78.6%	64.3%	14.3%	81.8%	64.5%	54.8%	9.7%	85.0%	-35.5%	-38.3%	2.9%	-8.2%
Eco compass	34.1%	2.3%	31.8%	6.7%	31.0%	2.4%	28.6%	7.7%	25.8%	0.0%	25.8%	0.0%	-8.3%	-2.3%	-6.0%	-6.7%
Eco circle	86.4%	63.6%	22.7%	73.7%	59.5%	40.5%	19.0%	68.0%	58.1%	41.9%	16.1%	72.2%	-28.3%	-21.7%	-6.6%	-1.5%
Material flow analysis	77.3%	43.2%	34.1%	55.9%	73.8%	45.2%	28.6%	61.3%	51.6%	29.0%	22.6%	56.3%	-25.7%	-14.1%	-11.5%	0.4%
Product line analysis	54.5%	20.5%	34.1%	37.5%	42.9%	9.5%	33.3%	22.2%	32.3%	12.9%	19.4%	40.0%	-22.3%	-7.6%	-14.7%	2.5%
Quality circle	84.1%	63.6%	20.5%	75.7%	69.0%	52.4%	16.7%	75.9%	61.3%	48.4%	12.9%	78.9%	-22.8%	-15.2%	-7.6%	3.3%
Eco benchmarking	75.0%	40.9%	34.1%	54.5%	57.1%	26.2%	31.0%	45.8%	54.8%	32.3%	22.6%	58.8%	-20.2%	-8.7%	-11.5%	4.3%
Eco sponsoring	84.1%	50.0%	34.1%	59.5%	64.3%	31.0%	33.3%	48.1%	54.8%	35.5%	19.4%	64.7%	-29.3%	-14.5%	-14.7%	5.2%
Environmental mgmt system	100.0%	86.4%	13.6%	86.4%	95.2%	83.3%	11.9%	87.5%	87.1%	80.6%	6.5%	92.6%	-12.9%	-5.7%	-7.2%	6.2%
Eco audit	100.0%	81.8%	18.2%	81.8%	92.9%	73.8%	19.0%	79.5%	83.9%	77.4%	6.5%	92.3%	-16.1%	-4.4%	-11.7%	10.5%
Risk analysis	93.2%	77.3%	15.9%	82.9%	78.6%	71.4%	7.1%	90.9%	77.4%	74.2%	3.2%	95.8%	-15.8%	-3.1%	-12.7%	12.9%
Green/Eco marketing	84.1%	36.4%	47.7%	43.2%	47.6%	7.1%	40.5%	15.0%	45.2%	25.8%	19.4%	57.1%	-38.9%	-10.6%	-28.4%	13.9%
Eco label	95.5%	34.1%	61.4%	35.7%	71.4%	28.6%	42.9%	40.0%	61.3%	41.9%	19.4%	68.4%	-34.2%	7.8%	-42.0%	32.7%
Average	79.5%	50.5%	29.1%	58.9%	63.7%	37.0%	26.7%	52.0%	55.8%	35.5%	20.3%	56.7%	-23.7%	-15.0%	-8.8%	-2.2%

Tab. D: Development of decreasingly known tools between 2002, 2006 and 2010

	2002				2006				2010				between 2002 and 2010			
Tool	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**known**	**applied**	**k-a gap**	**applied/ known**	**knowledge increase**	**application increase**	**k-a gap increase**	**applied/ known increase***
Environmental accounting	45.5%	18.2%	27.3 %	40.0%	40.5%	16.7%	23.8 %	41.2%	41.9%	9.7%	32.3 %	23.1%	-3.5%	-8.5%	5.0%	-16.9%
Opportunity risk dialogue	40.9%	22.7%	18.2 %	55.6%	28.6%	11.9%	16.7 %	41.7%	35.5%	6.5%	29.0 %	18.2%	-5.4%	-16.3%	10.9%	-37.4%
Social accounting	34.1%	9.1%	25.0 %	26.7%	28.6%	9.5%	19.0 %	33.3%	22.6%	3.2%	19.4 %	14.3%	-11.5%	-5.9%	-5.6%	-12.4%
Eco budgeting	38.6%	6.8%	31.8 %	17.6%	21.4%	2.4%	19.0 %	11.1%	25.8%	6.5%	19.4 %	25.0%	-12.8%	-0.4%	-12.5%	7.4%
Eco compass	34.1%	2.3%	31.8 %	6.7%	31.0%	2.4%	28.6 %	7.7%	25.8%	0.0%	25.8 %	0.0%	-8.3%	-2.3%	-6.0%	-6.7%
Cross impact analysis	15.9%	6.8%	9.1%	42.9%	23.8%	4.8%	19.0 %	20.0%	29.0%	6.5%	22.6 %	22.2%	13.1%	-0.4%	13.5%	-20.6%
Community advisory panel	27.3%	18.2%	9.1%	66.7%	31.0%	7.1%	23.8 %	23.1%	41.9%	9.7%	32.3 %	23.1%	14.7%	-8.5%	23.2%	-43.6%
Environmental shareholder value	47.7%	15.9%	31.8 %	33.3%	28.6%	4.8%	23.8 %	16.7%	41.9%	16.1%	25.8 %	38.5%	-5.8%	0.2%	-6.0%	5.1%
Environmental investment appraisal	36.4%	6.8%	29.5 %	18.8%	23.8%	2.4%	21.4 %	10.0%	29.0%	9.7%	19.4 %	33.3%	-7.3%	2.9%	-10.2%	14.6%
Average	35.6%	11.9%	23.7 %	34.2%	28.6%	6.9%	21.7 %	22.7%	32.6%	7.5%	25.1 %	22.0%	-3.0%	-4.3%	1.4%	-12.3%

Tab. E: Development of less well-known tools (knowledge < 50.0% in 2002, 2006 and 2010) between 2002, 2006 and 2010