DO SME NEED ONTOLOGIES?
Results from a Survey among Small and Medium-sized Enterprises

Annika Öhgren and Kurt Sandkuhl
School of Engineering at Jönköping University, P.O. Box 1026, 55111 Jönköping, Sweden

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Abstract: During the last years, an increasing number of successful cases of using ontologies in industrial application scenarios have been reported, the majority of these cases stem from large enterprises. The intention of this paper is to contribute to an understanding of potentials and limits of ontology-based solutions in small and medium-sized enterprises (SME). The focus is on identifying application areas for ontologies, which motivate the development of specialised ontology construction methods. The paper is based on results from a survey performed among 113 SME in Sweden, most of them from manufacturing industries. The results of the survey indicate a need from SME in three application areas: (1) management of product configuration and variability, (2) information search and retrieval, and (3) management of project documents.

1 INTRODUCTION

During the last years, an increasing number of successful cases of using ontologies in industrial application scenarios have been reported, see for example (Lau and Sure, 2002) and (Sandkuhl and Billig, 2007). However, the majority of these cases stem from large enterprises, or IT-intensive middle-sized or small enterprises (SME). Most SME outside the IT-sector probably never have heard about ontologies. Do these SME really need ontologies? Are there shortcomings and a need for improvement in application areas where the use of ontologies can create substantial benefits? Existing studies about IT use in SME, like (Lybaert, 1998), do not cover ontologies or knowledge representation techniques sufficiently. Studies focusing on usage of innovative ICT technology, like (Koellinger, 2006), target a wider audience than SME.

Considering the characteristics of successful cases in larger enterprises, similar cases should also exist in SME, but drawing conclusions from experiences of larger enterprises with regards to SME is not recommendable, as SME have their own characteristics (Levy et al., 2002): SME often belong to the group of ”late adopters” of new technology, i.e. they prefer mature technologies, which are easy to deploy, use and maintain. SME show a clear preference for to a large extent standardised solutions. Innovation projects in SME typically have to create business value within a short time frame.

The intention of this paper is to contribute to an understanding of potentials and limits of ontology-based solutions in SME with a focus on ontology application areas. The paper is based on results from a survey performed among SME in Sweden. The remainder of the paper is structured as follows: in section 2 we discuss background work together with the aim of the conducted survey. The survey setup is described in section 3. In section 4 the results of the survey are described. A discussion of the survey results regarding aim etc. is found in section 5. Finally, in section 6 conclusions are drawn.

2 BACKGROUND

This chapter briefly illuminates three aspects, which form an important background for the remaining part of the paper.

- In section 2.1: For what purpose and in what areas could SME possibly use ontologies?
- In section 2.2: How to judge whether there is an application potential in the identified areas?
- In section 2.3: To which research activities in ontology engineering is the survey supposed to contribute?

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2.1 Application Areas for Ontologies

The literature in the area of ontology engineering identifies a variety of different applications in many different areas. In (Obitko, 2001) the authors describe some: ontologies can be used for expressing domain-general terms in a top-level ontology, for knowledge sharing and reuse, for communication in multi-agent systems, natural language understanding, and to ease document search to mention some of them.

Uschold and Grüninger specify three different categories where ontologies can be used, see (Uschold and Gruninger, 1996). The first is communication: ontologies can be used to increase and facilitate communication among people. The second usage area defined is inter-operability. Ontologies can serve as an integrating environment for different software tools. The third usage area is systems engineering, in which ontologies can play an important part in the design and development of software systems. They can help to identify requirements of a system and to explicitly define relationships among components of a system. They can also be used to support reuse of modules among different software systems.

In (McGuinness, 2002) several application areas for ontologies are mentioned. Ontologies can be used for navigation, browsing, and search support. Consistency checking can also be handled with ontologies to some extent. Ontologies can provide configuration support and support validation and verification testing of data.

Within OntoWeb four different usage areas for ontologies are defined, as seen in (Ontoweb, 2004): enterprise portals and knowledge management, e-commerce, information retrieval, and portals and web communities. In this context, information retrieval means to use ontologies for understanding the concepts being searched and avoid the mistake of missed positives (failure to retrieve relevant answers) and false positives (retrieval of irrelevant answers).

When analysing the above sources, four application areas of ontologies in enterprises are named several times. These four application areas will be used as starting points for identifying ontology application fields of relevance for SME:

- navigation, browse, and search support for information retrieval in enterprises or for managing documents,
- capturing and representing knowledge for the purpose of knowledge sharing,
- configuration and validation support of products like software systems,
- supporting inter-operability between different IT-systems, e.g. in a collaboration between customer and supplier.

2.2 How to Judge Ontology Application Potential?

The previous section identified application areas for ontologies, which potentially are of interest for SME. One task of the planned survey will be to confirm that these fields really can be found in the SME sample under consideration, i.e. that a sufficient part of the SME have product configuration challenges, need support in document or information retrieval, or work in collaboration projects with suppliers requiring inter-operability.

The mere existence of an application field alone, however, does not indicate that the use of ontologies is appropriate in this field. Small projects or simple product configurations, to just take two examples, might well be manageable in an efficient way without any IT support at all. How to judge when it makes sense to consider the use of ontologies? In this paper we will follow the opinion of various scholars in the field that the complexity of an application case is an essential parameter to take into account when deciding about the use of ontologies. The more complex the application scenario, the more likely the usefulness of ontologies. In the context of this paper, project complexity and product complexity are of particular interest. Approaches for determining or even measuring project complexity and product complexity could directly contribute to identifying the share of SME with either complex project situations or complex products.

A review regarding the concept of project complexity performed by Baccarini (see (Baccarini, 1996)) proposes to define complexity as ”consisting of many varied interrelated parts”, to distinguish between organisational and technological complexity, and to operationalise this in terms of ”differentiation and interdependence”. Differentiation refers to the *number of varied elements*, e.g. tasks or components; interdependence characterises the interrelatedness between these elements. Regarding organisational complexity, Baccarini identified among other indicators the *number of organisational units involved* and the division of labour. For technological complexity, the diversity of inputs and output and the *number of specialities* (e.g. subcontractors) are considered.

In the area of product complexity, work of Hobday, see (Hobday, 1998), regarding distinctive features of complex products and systems identifies dimensions defining the nature of a product and its com-

plexity. The not exhaustive list of 15 critical product dimensions provided by Hobday includes *quantity of sub-systems and components*, *degree of customisation of products* and *intensity of supplier involvement*. These dimensions will be used in combination with Baccarini's project complexity indicators when evaluating the survey results in section 5.

2.3 Previous Work on Ontology Construction Methods

The work presented in this paper is part of a research program focusing on industrial applications of enterprise ontologies, with particular focus on SME. The overall intention is to lower the threshold for adaptation of ontology-based applications in industry by reducing time and costs for ontology development. Previous work focused on analysing existing ontology development methods with respect to their suitability for SME, see (Öhgren and Sandkuhl, 2005), and on proposing and applying a newly developed method in this context, see (Blomqvist et al., 2006). Although the initial experiences with the new method were positive, the conclusion was that a further specialisation would be recommendable.

In order to prepare this specialisation, the demands of SME and the relevance of ontologies for different application fields had to be investigated. The survey presented in this paper was performed in order to contribute to this objective. Thus, the survey focused on the applications, requirements and shortcomings perceived by the users in the enterprises rather than on the IT-solution aspects, i.e. details of IT-infrastructure or IT in use.

3 SURVEY SETUP

Based on the background work described in 2.1, the following five conjectures were defined regarding the application areas for ontologies in SME.

1. There is a need for supporting information searching and thus reducing the time needed to find the right information.
2. There is a need for supporting management of configurations or variations of products. This could be differences and similarities, dependencies between variants of a product, or dependencies between products, which could be used for example to improve reuse of parts of products and/or reuse of design processes.
3. There is a need for structuring documents and supporting document management, for example in order to support project work.
4. There exists a need for supporting collaboration and inter-operability in networks of companies, and/or supply chains.
5. There is a need for capturing enterprise knowledge, like development rules, process knowledge, or design principles in order to avoid dependencies from certain individuals.

3.1 Interviews

Prior to the survey interviews were held in order to investigate how to proceed within the previously discussed application areas. In total eleven people from seven companies were interviewed to see their view on potential problems and ideas regarding the conjectures and to identify suitable fields and questions for a questionnaire survey. The companies' sizes ranged from three employees up to 2300. The companies also differed in type and industrial sectors.

The interviews resulted in the decision to go on with a questionnaire to further investigate the first three conjectures listed above, namely information searching, configurations/variants of products and document management.

According to the interviewees most information within the field of supply chain or networks of enterprises is based on personal experience, which was deemed very hard or even not possible to document. The conclusion here was not to continue with the two last conjectures, i.e. with both supply-chains and network of enterprises, and documenting expert knowledge.

3.2 Survey Layout

The questionnaire finally consisted of 35 questions on six pages. The questionnaire was divided into six parts in varying size, where the first four questions concerned the company: number of employees, yearly turnover, industrial sector, and the respondent's role within the company.

The next part was related to conjecture 1, included ten questions, and dealt with document and information management. This part included questions about how much time the respondent used daily to find and save information connected to his or her work, where to find this information, etc.

The third part, which was connected to conjecture 3, concerned only companies working in projects and included six questions about the number of employees in each project, how long time the projects ran, and some information about the documents in the projects.

The following eleven questions were related to conjecture 2 and targeted only producing companies. These questions addressed how many products the company had, how many components each product consists of, how many suppliers that contribute to each product, and in how many variants each product is made.

Finally there were questions regarding non-documented personal knowledge and regarding taxonomies and nomenclatures. The answers to these questions will not be discussed in section 5 as they are not related to the conjectures.

3.3 Sample

In order to reach out to an appropriate number of companies, the schools host company database was used. These companies already have a connection to the school and were therefore deemed more interested in responding to such a questionnaire than companies without an established connection to the education and research performed at the school. The database also includes contact persons at each company, to whom the questionnaire was directly addressed to.

The questionnaire was sent to 436 companies in the end of 2005. 24 of the sent questionnaires came back unopened due to wrong addresses or unknown addresses, which means that the number of possible respondents was reduced to 412. 164 answers were received, all of them were considered useful and were used in the analysis, giving a response rate of 39,8% (164/412), which is considered to be quite high.

Among the 164 returned questionnaires, 51 were returned by large companies, i.e. companies with more than 250 employees or more than 400 Mio SEK yearly turnover (approx. 43 Mio EUR). The size of the sample taken into account for this paper is 113 small and medium-sized enterprises with approx. half of them with less than 50 employees.

4 SURVEY RESULTS

This section presents the results of the survey. The section is structured into three parts, which correspond to the conjectures introduced in section 3: retrieving information and documents (4.1), product complexity (4.2) and document management in projects (4.3).

4.1 Retrieving Information and Documents

In the survey, a clear majority of the sample perceive that they receive ”far too much” (41%) or ”too much information (28%). 27% think the amount of information is adequate, only 4% think they do not receive enough information.

Regarding the time needed daily to find the right information for the work at hand, the distribution is as shown in figure 1. Even though half of the sample needs less than half an hour daily to find the right information, it can be noted that a substantial part of the working hours is consumed by searching for information. 33% of the sample consume up to an hour daily, 11% need more than one hour, 5% even more than two hours.

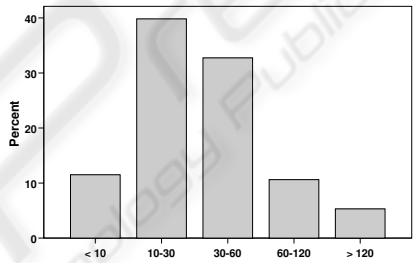

Figure 1: Time needed daily to find the right information for the work at hand (in minutes).

The participants were also asked how difficult it is to find the information needed for the work task at hand. Within the sample, nobody answered that it is ”very difficult” to find the required information. ”Relatively easy” and ”medium difficult” both received approx. 40%; ”very easy” and ”difficult” both approx. 9%. Not surprisingly, the respondents with a higher daily time effort for finding information also had a tendency to perceive it as more difficult to find the right information.

Concerning the sources for finding required information, joint file servers in the companies and the Internet are the most often used sources, followed by the own PC: 70% answered that the file server is ”often” or ”very often” the source for information, 64% the Internet and 49% the own PC. Intranet and document management systems (DMS) are less frequently used (36% and 26%, respectively), which to some extent will be based on the fact that 29% of the sample do not have an Intranet and 31% do not have a DMS.

The established DMS and Intranet solutions in enterprises are used quite intensively: 40% of all respondents use these systems several times a day, 29% nearly every day. 17% use these IT-systems a few times during the week and 14% use them only a few

times in a month or even more seldom.

Regarding the question how to find the requested information in the above mentioned sources, most respondents rely on their memory from earlier cases (67%), use keyword search (60%) or the existing directory structure (59%). Furthermore, a substantial part of the respondents ask their colleagues for the needed information (29%).

Considering the potential for improving information management in SME, not only the introduction of Intranet or DMS in companies without those system types is a possibility, but also the improvement of these systems as such. Among the respondents who have an Intranet or DMS 50% of the respondents note that it is not possible to subscribe new or changed information, 17% stated that they got too many hits when searching for information, 19% claimed they got irrelevant hits, and others wish for an improved structure of the information, either with relation to the work process (19%), or with regards to the product structure used in the company (33%).

4.2 Product Complexity

Another part of the survey was addressing the issue of product complexity. In industry domains developing or manufacturing physical products, the number of components in the product, potential versions and variants of the product and number of suppliers contribute to product complexity. The product related part was answered by 61 of 113 SME. The following part of the results is based on these 61 responses.

The number of products found in the sample was quite high: 62% of all respondents stated that they have more than 50 products. 5% and 13% have between 11 and 25 or between 26 and 50 products, respectively. 15% of all respondents have between 4 and 10 products, 5% even less than 4 products.

Most of the products have a small number of variants. 47% of the respondents answered that there are on average less than 6 variants, 23% between 6 and 12. 4% stated that there are between 13 and 25 variants, 9% between 26 and 50, and 17% more than 50 variants.

The average number of components in these products is either quite high or quite low. 35% of the respondents state that a product on average has more than 50 components. 42% have less than 10 components per product (23% less than 4 components; 19% between 4 and 10). 21% state the average number is between 11 and 25. At 2% of the respondents it is between 26 and 50.

In the large majority of the enterprises, a description is available which components are parts of what product: 88% answered that some kind of product structure exists, 8% answered there is no such structure, the remaining did not know. The existence of such a description or product structure would ease the development of an ontology in the field of variability management.

The average number of suppliers contributing to a product is less than 3 at 16% of the respondents, between 3 and 5 at 27%, between 6 and 9 at 16%, between 10 and 15 at 15% and more than 15 at 26% of the participating SME.

Reuse of components in new products or new variants of an existing product could be improved considerably, according to the opinion of a majority of the respondents. 26% state that currently there is no reuse of components at all, 15% answer that there is nearly no reuse. 26% answer that reuse happens sometimes, 20% state that reuse happens often, 13% very often. On the question whether it would be possible to reuse more, 16% respond ”definitively possible”, 48% ”yes, probably” and 36% think it is not possible.

4.3 Document Management in Projects

The survey also included a number of questions on projects performed in the enterprises. Main intention was to investigate the complexity of projects performed and the documentation involved. The project related questions were answered by 71 out of in total 113 SME participating in the survey. The following part of the results is based on these 71 answers.

In order to get information about project complexity, the survey included questions about the number of project members, run time, number and volume of project documents, structure and content of project-related documents. Based on the respondents' answers, the projects in SME are rather small in terms of project members. 39% state a project has only up to 3 members, 51% have between 4 and 8 members and only 10% have more than 8 members. The large majority of the projects has a run time of more than one month but less than one year: 39% state that the average project run time is between 1 and 4 months, 32% have an average run time between 4 and 12 months. Enterprises with average project length of less than one month (20%) and more than one year length (9%) are in the minority.

The number of documents produced in a project varies considerably within the sample: 37% of the respondents state that there are on average less than 10 documents, 35% between 11 and 25 documents, 13% between 26 and 60, and 15% more than 60 documents in a project.

Most of the documents are quite small in terms of

number of pages. 51% state that the documents on average have less than 4 pages and 37% between 4 and 10 pages. Only 10% of the respondents have an average document size of between 11 and 25 pages, 3% between 26 and 50 pages.

Regarding the document structure, standardisation seems to be common practise. In more than 85%, the document structure is identical in different projects (38%) or nearly identical (47%). 11% state that the structure sometimes is similar. A not at all similar structure in different projects can be found only at 4% of the respondents.

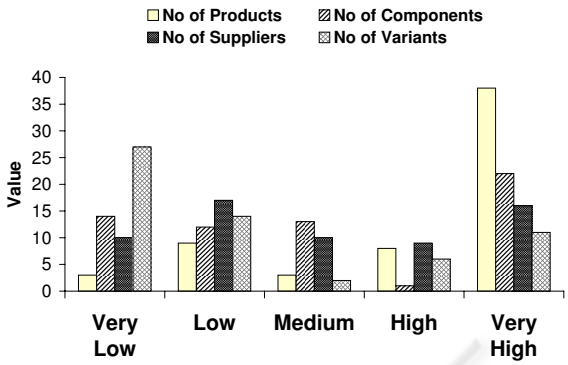

Figure 2: Distribution of very low to very high for the four product-related criteria.

5 DISCUSSION

The first conjecture addressed the *need for supporting search and information retrieval* in SME. Experiences from using ontologies for structuring information or within search engines show clearly that they can contribute to improving precision. Examples for investigation in this field can be found in (Ciravegna and Petrelli, 2006) and (Redon et al., 2007). However, the main question to discuss from an SME perspective is which approach creates the best benefit/effort ratio, i.e. substantial benefits at a reasonable price.

As a considerable part of SME neither have Intranets or DMS, and as even the established systems have improvement potential, these improvements should be made first before starting on ontology development.

Thus, our conclusion regarding use of ontologies for supporting information management in SME is:

- the SME participating in our survey perceive diverse information management problems, like difficulties to find the right information, shortcomings in the established IT-systems or information overload. This presents an application field for ontologies,
- the use of conventional technologies should be given preference to ontologies when improving information management in SME.

The second conjecture addressed the need for *supporting management of product configuration and variation*. The fact that 61 of 113 SME responded to the questions regarding product variability in the survey gives a first indication that many SME actually provide physical products consisting of various parts. In section 2.2 the concept of product complexity was briefly discussed including indicators for product complexity. For the purpose of evaluating the product complexity in the sample, we included four criteria, which are connected to four questions in the survey:

- number of products,
- average number of components per product,
- average number of suppliers per product,
- number of variants.

These four criteria match directly to the indicators proposed by Baccarini and Hobday (see 2.2). For each of these four criteria, the survey questions offered five different choices. Mapping these choices on a scale from ”low” to ”very high”, i.e. the choice with the lowest number of products, components, variants and suppliers is mapped to ”low” and the choice with the highest number is mapped to ”very high”, helps to visualise the distribution of the answers regarding the four criteria. Figure 2 shows this distribution.

Furthermore, it is important to know whether there is a correlation between the four criteria, for example whether companies with a high number of products also have a high number of variants and many suppliers. When investigating this aspect, we found 31 cases with at least two criteria receiving at least ”high”. Of these 31 cases were 21 with two times ”very high” and 16 with three times at least ”high”. Figure 3 visualises these 16 cases.

In terms of complexity, we consider at least the 16 cases shown in figure 3 as complex enough to seriously investigate the use of ontologies. The 16 cases show both, a very high degree of differentiation and interdependencies between the criteria. Even for the other 15 cases, who at least receives two times ”high” or ”very high”, we see development potentials for ontologies, as all of them at least have one criteria on ”medium” level, which contributes to substantial differentiation and interdependencies.

Based on the above discussion, we conclude that there is a need for supporting variability management. Approximately a quarter of all SME in the sample

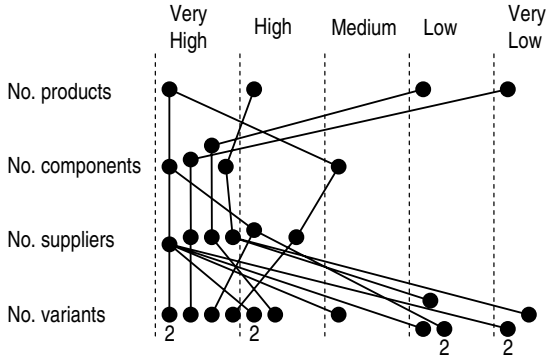

Figure 3: Cases from the survey with highest product complexity.

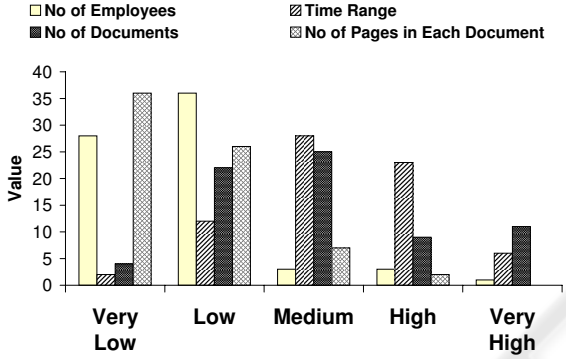

Figure 4: Distribution of very low to very high for the four project document management-related criteria.

and more than half of those SME answering the product related questions have a substantial complexity in their product portfolio.

Conjecture 3 focused on the need for *supporting document management in project work*. 71 of 113 SME responded to the questions regarding project work, which indicates that many SME actually use project organisation based on documents. Evaluating the complexity of document management in projects again included four criteria, which are connected to questions in the survey:

- average number of employees in a project,
- average number of documents per project,
- average duration of projects,
- average number of pages per documents.

The first two criteria directly relate to Baccarini's work (see 2.2); the other two were derived in order to represent document complexity. The survey questions offered five different choices for each of these four criteria, which were mapped on a scale from "low" to "very high". Figure 4 visualises the distribution of the answers regarding the four criteria.

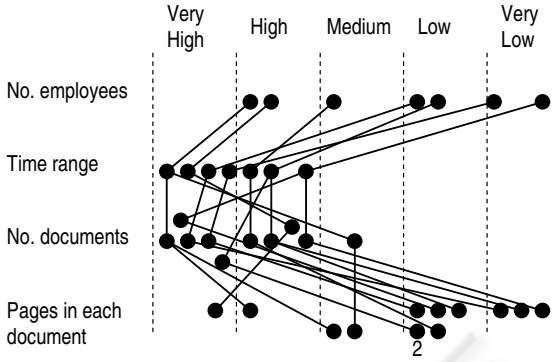

Figure 5: Cases from the survey with highest project document management complexity.

Considering the correlation between the four criteria, we found 13 cases with at least two criteria receiving at least "high". Of these 13 cases were 5 with two times "very high". Figure 5 visualises these 13 cases.

In terms of complexity, we consider at least the 13 cases shown in figure 5 as complex enough to seriously investigate the use of ontologies. These cases show both, a very high degree of differentiation and interdependencies between the criteria. Comparing these figures with the situation in product complexity (conjecture 2), the significance of a need for supporting project document management is not as high. However, 18% of the SME working in project organisation and 11% of all SME in the sample show a high complexity, which from our perspectives is sufficient motivation to aim at supporting project document management.

6 CONCLUSIONS

The main purpose of this paper is to contribute to research on ontology development methods by investigating, which application areas for ontologies in SME could motivate the development of specialised ontology construction methods. The performed survey was guided by five conjectures intended to help in identifying such areas, which can be used to summarise the conclusions.

- There is a need for supporting information searching: the survey results clearly confirmed this conjecture. However, existing tools like DMS could be used to support these needs.
- There is a need for supporting management of configurations or variations of products: again, the survey results clearly supported this conjecture.

- There is a need for structuring documents and support of document management: the survey results supported this conjecture, but not to the same extent as in the first two conjectures.
- There exists a need for supporting collaboration and interoperability in networks of companies: this conjecture was not included in the survey, as the interviews performed prior to the study indicated significant problems in capturing sufficiently detailed information with ontologies.
- There is a need for capturing enterprise knowledge: again, this conjecture was not further investigated after the interviews, as big concerns were expressed that capturing personal knowledge would be feasible.

Thus, the conclusion from the survey is that SME need ontologies mainly in the area of product configuration and variability modelling. This application area will be given highest priority when developing a purpose-oriented ontology construction method. The application area with the second highest priority is document management for supporting project work. This area can be seen as a sub-area of information search and retrieval with specific focus on project support.

Regarding the last two conjectures, we received a number of indications in the interviews and even within the survey, that application potential of ontologies could exist for capturing knowledge in SME and for supporting supply chains. However, this is not perceived as a priority area by the SME and will thus have the lowest priority in future work.

The main limitations of the survey are:

- the survey only included SME from a geographically limited area, which is the south of Sweden,
- the majority of SME participating in the survey were manufacturing companies,
- the size of the sample was not large enough for achieving results of statistical significance.

These limitations should be taken into account when investigating whether the results are transferable to other areas or applicable in other research contexts.

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