A Measurement Model to Identify Knowledge-intensive Business Processes in SMEs

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Abstract: This paper is based on earlier work about the selection of knowledge-intensive business processes in SMEs done by the author with the result of defining 15 different factors in four categories: process, people, task and interdependencies. The developed factor model for describing the knowledge-intensive business process is driven further within the last year to help small and medium sized enterprises to focus on their important business processes if starting with process management initiatives. The developed factor model was enriched with a measurement model that combined scientific and practical input. This paper presents the measurement model that is at least able to divide between knowledge-intensive business processes and not knowledge-intensive business processes in a company. It is essential to invest in the right business processes for improvement if it comes to process management according adopting current challenges for SMEs, which are fulfilling any quality management norm like ISO 9000 series.

1 INTRODUCTION

Knowledge serves as the basis for a competitive advantage that can be maintained over the long term (Nonaka and Takeuchi, 1998). It can thus be deduced that one way of securing corporate activity in the long term could be for companies to learn faster than their competitors (Senge, 1996). The efficiency with which knowledge is processed in companies is a decisive factor in ensuring a company's continued existence. The consistent cultivation of specific experience is developing into a priority management task for companies (Probst et al., 2006).

The discussion on knowledge management has mostly focused on large companies. Topics such as corporate culture, stakeholder networking, organizational structures, and technologically based infrastructures were examined based on the implementation of knowledge management in large companies. However, no focus was placed on the unique needs of small and medium-sized enterprises (SMEs) (Delahaye, 2003). Knowledge management has also become a crucial task in SMEs (Durst and Edvardsson, 2012) (Salojärvi et al., 2005). Desouza and Awazu (Desouza and Awazu, 2006) believe that SMEs can achieve their competitive advantage by actively managing their knowledge. McAdam and Reid (McAdam and Reid, 2001) also point out the importance of an independent view of SMEs. A comparative empirical study by the two authors shows that both large companies and SMEs can benefit from implementing knowledge management. Dunkelberg and Wade (Dunkelberg and Wade, 2007) think that a conscious and systematic implementation of knowledge management has a positive influence on the development of a company.

According to Edwards and Kidd (Edwards and Kidd, 2003), there are four possible approaches to implementing knowledge management in companies: (1) the "Knowledge World" way, (2) the "IT-driven" way, (3) the "Functional" way and (4) the "Business Process" way and some of the reasons for the "Business Process" way are already given. For this paper, the focus on the "Business Process" way selected because of the current developments regarding changes in the area of auditing based on quality management norms. Current developments in the area of ambidexterity and agile auditing are one of the main topics of the author's research unit, where the whole team is currently doing much empirical work in. From a practical point of the changes in the last versions of quality management norms like ISO 9001, ISO 14385, and so on, develop into a more agile idea of auditing developing companies to the permanent audit readiness. Fur-

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thermore, this work should help companies to filter their business processes by the most important ones to put effort into these processes first to fulfill the external requirements and improve internal governance.

Based on this problem description, the following research question can be determined: How can a measurement model for knowledge-intensive business processes look like for SMEs?

To answer this research question the theoretical foundation will be built up in section 2 followed by a short explanation of the related work in section 3. The conducted empirical study will be explained in section 4 followed by the results and a discussion given in section 5. A conclusion is given in section 6 followed by the limitation and future research in section 7.

2 THEORETICAL FOUNDATION

The two main concepts needed for this study are, on the one hand, the model concept and the term of the knowledge-intensive business processes. Both of these concepts are described in the tow following subsections.

2.1 The Model Concept

The formation of a model to describe a specific section of reality is called modeling. Analysis and structuring of the given data material lead to the formation of concepts and, thus, to a structural concept for the model. The model subdivides the examined section of reality by assigning a system of concepts to the unstructured initial data and thus determines their meaning and their relationships with each other. The structural concept always considers only one particular view of the section of reality to be modeled (Heinrich et al., 2014, p. 437). The following statements all refer to the model which is created in the course of this work, and the forms of expression are explained accordingly:

- The object type is a process model. The model to be created will describe the process of diagnosis. The individual process steps can be derived from the model and operationalized. It thus describes the path of diagnosis in addition to the description of the real-world object.
- The degree of formalization of the model describes its description possibilities. The model to be formed in this thesis can be described as formal because it can be fully represented utilizing mathematical symbols. However, this does not exclude another form of representation but represents a minimum requirement.
- A mathematical representation of the model is decisive for a corresponding classification in the criterion of the form of representation. The model to be created serves as a possibility to differentiate between knowledge-intensive and non-knowledge-intensive business processes based on evaluated criteria that can be put into a mathematical context. A mathematical representation, therefore, becomes inevitable. In order to present the process of diagnosing in a more comprehensible way, graphic forms of representation will also be necessary. Thus, there is no double mention of the form of representation in the special case of the diagnosis model.
- The model forms the basis for differentiating whether a particular process is a knowledge-intensive or a non-knowledge-intensive business process - which is why a decision is ultimately made.
- The causality structure can be assumed to be linear since a linear relationship can be established between the elements with their characteristics and their effects on the model. Furthermore, no feedback on the elements is possible.
- The model to be formed in work is not a meta-model since it does not contain construction rules and interpretation hints of models. These two requirements would indicate a meta-model.

In summary, it can be said that the division, according to Heinrich et al. (Heinrich et al., 2014) is a descriptive model that is formed inductively. The requirement of structural similarity cannot be fulfilled due to the exploratory character of the model and the associated uncertainty about the number of elements and their relations - however, structural similarity can be assured based on empirical findings. The validity of the model is ensured due to a methodically clean procedure in model building.

2.2 The Knowledge Intensive Business Process Concept

Separate consideration of knowledge-intensive business processes can be seen as positive from several perspectives: A closer look at business processes (Dumas et al., 2013) and their supporting knowledge processes gives knowledge management a much stronger link to the value chain (Skyrme, 1998). Some author assume that a combined view has a positive effect on the design and implementation of knowledge management systems through the gained process reference (Mentzas et al., 2001). A combination of business process modeling with knowledge management activities can support change processes and innovation. Knowledge management is introduced for core processes (Davenport and Prusak, 2000) and supports them efficiently (Mertins et al., 2001). These and other aspects of (Oesterle and Winter, 2000) can be seen as important advantages of a combined approach (Remus, 2002).

Since there is currently no clear definition for knowledge-intensive business processes, the following section presents some definitions that need to be considered in a differentiated manner and from which a definition that is useful for the work is worked out, which will determine the further procedure. Finally, as a result of the present work, a model will be developed, which tries to divide between knowledge-intensive and non-knowledge-intensive business processes possible using factors.

In a paper by Goesmann and Hoffmann (2000), a definition of the term knowledge-intensive business processes is presented as follows: ”Processes [...] with a high proportion of information processing activities, in which unpredictable information requirements arise and new information is frequently generated [...]. Further characteristics are [...] high adjustment requirements and high decision-making leeway of the employees” (Goesmann and Hoffmann, 2000). This definition shows a technocratic understanding of knowledge-intensive business processes.

With Remus (2002), on the other hand, a partial aspect of knowledge-intensive business processes can be seen as follows: ”...knowledge-intensive business processes make greater use of knowledge in the production of goods and services than conventional processes (Remus, 2002, p. 38). This definition is based on the concept of knowledge, which was coined from knowledge management, without going into its fuzziness in detail. Richter-von Hagen et. al. (Richter-von Hagen et al., 2005) offers a definition that also refers to this knowledge: ”A process is knowledge-intensive if its value can only be created through the fulfillment of the knowledge requirements of the process participants. From this, it can be seen that the corresponding process participants very often provide the required process knowledge and that the human factor must not be forgotten in a closer examination.

A further definition can be found in Maier (Maier and Thalmann, 2007, p. 212f), following Allweyer (Allweyer, 1998): ”This Term denotes a business process that relies substantially more on knowledge in order to perform the development of production of goods and services than a ”traditional” business process”. Furthermore, Maier (Maier and Thalmann, 2007) writes about knowledge-intensive business processes: ”...every type of business process is a potential candidate for a knowledge-intensive business process”. It is precisely this statement on the occurrence of knowledge-intensive business processes that calls for the elaboration of the present paper, the aim of which is to achieve a classification into knowledge-intensive and non-knowledge-intensive business processes.

As a summary of the different definitions presented here, it can be assumed that the description of a knowledge-intensive business process can by no means be dealt with in one sentence. The broad view that the knowledge-intensive business process is characterized by a higher knowledge share of the process participants is also supported in this thesis. Other additional factors which can be descriptive of the knowledge intensity of business processes are found, among others, in Eppler et al. (Eppler et al., 2008), Goessmann Hoffmann (Goesmann and Hoffmann, 2000), Gronau et al. (Gronau et al., 2005) or Remus (Remus, 2002).

3 RELATED WORK

As mentioned in the introduction, the factor model itself was developed and presented in earlier work (Ploder and Kohlegger, 2018) by the author and will only be described rough in this paper for better understanding of the measurement model. To build the factor model a study in Austrian SMEs was conducted based on the structured case approach (Carroll and Swatman, 2000) with the aim to find out which are the relevant factors to filter the knowledge-intensive business processes. Within three iteration steps the factor model has been developed and is shown in figure 1.

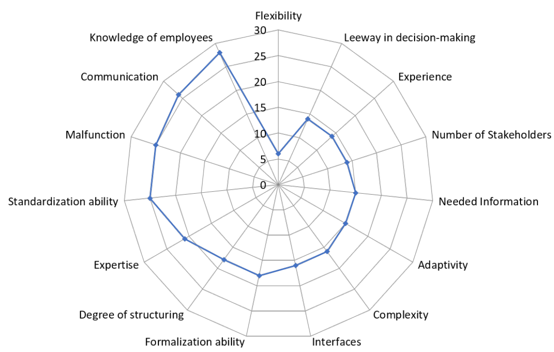

Figure 1: Factor model by frequency of responses.

All the factors have first been elaborated from literature and later on expanded by expert interviews to make a identification of the knowledge-intensive business processes possible. But there was no weighting and no calculation scheme available for the measurement of different processes in SMEs. How this calculation scheme was developed will be shown in the section 4.

4 EMPIRICAL STUDY

The empirical study was based on Austrian SMEs as defined by the EU based on the three factors: (1) headcount less than 250 employees, (2) transaction volume less than 50 Mio. Euro and (3) a balance sheet total of less than 43 Mio. Euro. However, there is a second limiting factor that is essential to this study's validity. This factor is the certification of the respective companies according to the ISO 9001 standard because these companies are familiar with the process management idea and have to deal with current developments like permanent audit readiness. In contrast to the first study, the data evaluation for this paper is quantitative because it is all about setting the measruements for the categroies and the factors itself. For this purpose, the results were transferred to a spreadsheet program and analyzed through statistical procedures (frequency analysis and concluding statistical values to check the data material).

Based on the first empirical study explained in Ploder and Kohlegger (Ploder and Kohlegger, 2018) the same experts have been interviewed for a second time in 2019 with a structured interview guideline to get answers on the following questions: (1) how can the measurement of the factors from the first three cycles be described, (2) how can the directions of action of the factors be described, (3) how can the distribution of the weightings of the four categories be described and (4) how could a mathematical model for evaluation look like. The generation of the questions was following the SPSS method to focus on the most important questions during the strict guided interviews (Helfferich, 2011).

To get answers on the four given questions, the interview guide was designed to be a quantitative study. In the first two questions, all 15 factors were given to the experts, which were then ranked by the experts on the one hand concerning their relevance (question 1) for distinguishing between knowledge-intensive business processes and non-knowledge-intensive business processes. On the other hand, the direction of effect (question 2) of the factors on the knowledge intensity of a process was determined. The relevance check was carried out using an ordinal scale from "very relevant" to "not relevant" for each factor. It is also important to note that it is the relevance of the factor and not its impact that is at issue.

The experts rated the direction of impact as positive or negative with maximum expression of the factor. An example of a negative direction of effect would be: "If the formalizability of a process is rated very high, this would rather indicate a non-knowledge-intensive business process".

Question three in the expert interview guidelines had to deal with the question of the weighting of the categories (question 3) and a calculation (question 4) based on this for the classification. For this purpose, four different scenarios with two differentiated approaches were chosen. These scenarios were specified in order to make it easier for the experts to make an assessment and to be able to determine a tendency from the expert interviews, which of them are suitable for the diagnosis model. The two differentiated approaches differ in that only a minimum value at achievable points of the 15 factors is decisive for the classification, and it can, therefore, be the case that a category is assessed as very low and yet an overall value indicates a rather knowledge-intensive business process. This approach has been given two different values for overall rating of all factors: Scenario one with 75 percent or scenario two with 50 percent.

Scenarios three and four, on the other hand, are based on the approach that a minimum value must be achieved both overall and in each category. To allow the experts to make an individual proposal, scenario 5 provides the opportunity to present a particular scenario.

5 RESULTS AND DISCUSSION

The evaluation of data gained from question 1 show that there is no factor which the experts consider to be irrelevant and all of them are taken for the measurement model as shown in table 1. The factors are listed in the columns and assigned to the corresponding categories. Based on the ordinal distributed data, an aggregated measure of the relevance of the individual factors is formed not with the mean value, but with the median. For the coding from "very relevant" to "not relevant," the numerical values were used in steps of 1 from 3 to 0. This shows that the majority of the factors were rated "relevant" or better. There was no factor which could be classified as "not relevant", which means that all factors can be used to build the model. The standard deviation of the respondents' statements on factor relevance can also be classified as appropriate from a statistical point of view. Very small deviations can be explained by a partially differentiated understanding of the factors by the experts.

The direction of action of every factor was also answered in question two, evaluated using the mode and is shown in table 1 (pos for positive / neg for negative). The direction of action of the factors provides information on whether a high level of the factor is a positive or negative indication of the business process's knowledge intensity under investigation. An initial analysis of the direction of action was already carried out during the first three cycles. Expert opinions additionally check these results. For example, a high standardization ability of a process is evaluated negatively on its knowledge intensity, which means that a process with a very high standardization ability is more likely to be a non-knowledge-intensive business process.

Table 1: Directions of effects for every factor.

Nr	Factor	Effect	Weight
	PROCESS		
1	standardization ability	neg	11%
2	formalization ability	neg	8%
3	complexity	pos	7%
4	needed information	pos	7%
5	scope for decision	pos	6%
6	malfunction	pos	4%
7	degree of structuring	neg	2%
	PEOPLE		
8	knowledge of employees	pos	12%
9	expertise	pos	9%
10	experience	pos	6%
	TASKS		
11	adaptivity	pos	7%
12	flexibility	pos	2%
	INTERDEPENDENCIES		
13	communication	pos	11%
14	number of stakeholders	pos	6%
15	interfaces	pos	2%

The evaluation of question two showed that no expert developed his own scenario 5, and thus an evaluation of the four given scenarios can be made. This evaluation of the data showed that scenario 3 emerged as the most frequently chosen scenario. From this output, two statements can now be set for measurement purposes: (1) It is essential to the experts that a step-by-step evaluation is carried out at category level and overall level; (2) The following two restrictions can be taken as restrictions for a classification of a knowledge-intensive business process: (a) at least 50% must be achieved per category and (b) in total at least 75% of the possible maximum score.

Question 3 on the weighting of the individual categories was evaluated by the experts as given: (1) process = 10%, (2) people = 50%, (3) task = 20% and (4) interdependencies = 20% . The mode was also used here as a statistical measure, which is represented in the form of the percentage values per category. The evaluation of this question leads to the conclusion that the human category is the most relevant category for this model, and the category of formal criteria is classified as the least relevant category.

Question 4 will be answered with the dedicated calculation steps that have to be performed and are given in section 6.

The author will point out that with the knowledge gained in this work, it will not be possible to achieve a clear separation between the two poles - thus, with the help of this model, a direction can be diagnosed, but no clear and precise separation can be established. The first step is to look at the processes in a company, and therefore, a list of all factors is necessary to apply the measurement model. The determination of the factors is explained, and an example of the measurement model is shown. In figure 2, the factor analysis template is given to be filled out by the process evaluation responsible.

pos	factor	effect	entirely true	partially true	hardly true	not applicable
1	standardization ability	neg				x
2	formalization ability	neg			x	
3	complexity	pos			x	
4	needed information	pos		x		
5	scope for decisions	pos	x			
6	malfunction	pos	x			
7	degree of structuring	neg			x	
8	knowledge of employees	pos	x			
9	expertise	pos		x		
10	experience	pos	x			
11	adaptivity	pos		x		
12	flexibility	pos	x			
13	communication	pos	x			
14	number of stakeholders	pos		x		
15	interfaces	pos	x			

Figure 2: Measurement Example - Template.

All 15 factors are provided with a scale. This ranges from ”completely correct” to ”not correct” with the two intermediate steps ”partially correct” and ”not correct at all”. This type of scale has been used because it has proved to be successful in practice to use scales with an even number of scores. After all, this forces the respondent to make a statement in one direction. An alternative would be to use a scale with an odd number of values, but which would then allow the middle to be selected. However, since the present study is a classification in the sense of "Yes - the process will be rather knowledge-intensive" or "No - the process will be rather non-knowledge-intensive", a selection of four points is preferred. The determination of the factor characteristics can then be carried out. For each factor, its value is entered, and thus the values of all factors for a process are recorded. The respective values are converted using the coding schemes listed in table 2. It is essential to differentiate the influence concerning the direction of action.

Table 2: Coding of the scale.

effect	entirely true	partly true	hardly true	not applicable
pos.	3	2	1	0
neg.	0	1	2	3

The assumption that the conversion sequence is reversed in the case of an adverse effect relationship can be explained by the fact that conversion by a change of sign would influence the calculation, but this does not describe the directional effect. It is, therefore, merely a matter of including the opposite direction as positive overall. This also offers the possibility to carry out the calculation relatively easily, either manually or computer-aided. The weight of the factor was mentioned in figure 3 and are combined with the information given in table 2 per factor and summed up per category. The last step is to rank the categories sum and build an overall sum for this, remarkably measured process, as shown in figure 3.

category	coded values	weighted factor	value weighted	category weight	category weighted
process	3	25%	0,75		
	2	18%	0,36		
	1	16%	0,16		
	2	15%	0,3		
	3	14%	0,42		
	3	8%	0,24		
	2	4%	0,08	10%	0,23
people	3	44%	1,32		
	2	33%	0,66		
	3	23%	0,69	50%	1,34
task	3	72%	2,16		
	3	28%	0,84	20%	0,60
interdep.	3	58%	1,74		
	2	31%	0,62		
	2	11%	0,22	20%	0,52
			Overall SUM		**2,68**

Figure 3: Measurement Example - Calculation.

6 CONCLUSION

Knowledge management and business process management are not only theory-based concepts from science but also practical possibilities to improve enterprises' efficiency through the application orientation of business informatics as a research discipline. In recent years, it has also been recognized that combining the two concepts, in the form of knowledge-intensive business processes, can achieve specific synergy effects (Remus, 2002).

It is precisely these synergy effects that can also be very beneficial for the long-term survival of a particular group of companies: small and medium-sized enterprises. This group of enterprises, with their specific requirements that must be differentiated from those of large enterprises, is mostly left out of the current discussion about knowledge-intensive business processes. The present work is to be classified precisely in this minimal researched area of business informatics. The aim was to develop a model for the diagnosing knowledge-intensive business processes in SMEs, whereby the diagnosis can be understood as the determination, examination, and classification of factors with the aim to split the whole process landscape in knowledge-intensive ones with a ranking and all the others to focus on the knowledge-intensive ones first if it comes to project management initiatives regarding the fulfillment of quality management norms.

To perform this differentiation, the following steps have to be performed for every process:

1. take the measurement template as given in figure 2 to evaluate the factors of a particular process
2. combine the information of the scale with the positive or negative coding given in table 1 and multiply that with the weight of the factor
3. take the sum of the values weighted and multiply that with the category weight given in the answer of question 3 and shown in the example in figure 3 - this leads to the category weighted values
4. sum up the category weighted and this represents the overall rating of the particular process
5. redo the given steps for all processes in the landscape, take the two formulated restrictions into consideration and build a ranking of all your business processes

Following all given five steps after the application of this measurement model, a company gets a structured overview of their more and less knowledge-intensive business processes to get an idea with which processes to start the improvements according to any process management initiatives or the application of a quality management norm.

7 LIMITATION AND OUTLOOK

There is one obvious limitation to this presented study: the missing application of the measurement model in practice. The author tried to implement all the necessary knowledge from practitioners and combined it with a scientific background, but there is a lack of practical evidence which should be improved by the next step in this research project.

The next goal is to specify the lack of calibration of the factors/restrictions and to substantiate this utilizing additional studies. In this context, the diagnostic model should be applied in companies, and a second measurement should be carried out using other methods. The two results can then be compared with each other, and new insights can be gained to improve the measurement ability and prove the whole concept.

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