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Creating the Knowledge-structured Texts in Agriculture Companies: A Cost Modeling Approach

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Abstract

Agriculture is one of the most regulated sectors. Council regulations, national legal acts, subsidies, nature protection, market regulations and many other directives induce the necessity to work with a lot of text documents and to manage the knowledge in them. Thus, it is worth considering the creation of specifically designed internal documents to represent knowledge explicitly in so-called "knowledge-structured texts". However, it is a costly process to create the knowledge texts. The objective of this paper is to create a model that is capable of showing what time point the successive costs of the two types of text are equal at. Linking the methods of knowledge engineering and management is carried out with the help of an integrating element, i.e. general systems theory, through system dynamics. Despite an initial investment in the knowledge texts, the results show their potential for lowering the costs in the middle- and long-term horizons.

Keywords

Agribusiness company, costs, knowledge-structured text, management documentation, normal text, system dynamics.

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Introduction

Today is no exception; in the context of an interdisciplinary collaboration between related disciplines that deal with recruiting and working with knowledge, it is the beginning of using the knowledge in the field of "knowledge engineering" not only in educational and teaching disciplines but also on the corporate level (Koczinsky and Somosi, 2016). Knowledge engineering provides a formal model for the representation of explicit knowledge, which is subject to the transfer and sharing in the classroom or during expert consultations, or as a part of management control by means of managing the documentation at the enterprise level.

Several authors, e.g. Jokonya (2016) or Brožová et al. (2011), highlight the importance of a general system theory and system approach for this purpose. System approach has also been used to derive new knowledge representation called "knowledge unit" (Dömeová et al., 2008). Houška and Rauchová (2013) indicate that the benefit of this representation is the ability to express a formal model of knowledge in natural language, which is more comfortable for a human user. The model of knowledge unit also allows to create educational texts, instructions or procedures that include knowledge in an explicit form (knowledge-structured texts).

Dalihod (2014) or Jokonya (2016) criticize the lack of the system approach and system thinking in business management and problem-solving within the managerial communication; they also state that nowadays, the situations are occurring more frequently where managers solving communication problems are limited to solving context without using the system approach and system thinking, which is absolutely necessary for system troubleshooting. System dynamics is based on the system approach, which is very useful in addressing the social-economical and managerial problems (Fowler, 2003). Furthermore, models of system dynamics describe systems not only in the context of knowledge transfer but also from the point of view of their derivation in particular, as expressed e.g. by Vennix et al. (1990) or Ford and Sterman (1998).

Dalihod (2014) uses system dynamics for modeling the problems of internal management communications. Sonea (2014) states that verbal communication management includes both verbal communication and writing, and in the case of written communication, it mainly deals

with the creation of text documents for general corporate communications (emails, reports, newsletters etc.). In the company, as a part of the process management, we still encounter other types of documents, called "management documents", e.g. the documentation for process control, management and information standards, operational documentation, basic organizational norms, or legislative and legal standards (Carbonell et al., 2016). Using the complexity of the individual documents, we can define three basic layers in a hierarchy of data-information-knowledge (Koczinsky and Somosi, 2016).

The aforementioned knowledge-structured texts, based on the system approach, can be used, as stated by Rauchová and Houška (2013), not only for the educational level as a replacement for textbooks but they can also be used in the context of corporate management documents for medium-sized businesses, large enterprises or corporations. The question is what their effectiveness and efficiency is, i.e. whether people who solve tasks according to instructions, directives and other documents are working with lower error rate and whether this advantage brings more savings than the costs of creating knowledge-structured texts as compared to the costs of classical works directives (Rauchová and Houška, 2013b). The system approach is also suitable for creating metric-based evaluation of the efficiency and effectiveness of knowledge transfer (Rosales et al., 2012). The issue of evaluating the effectiveness of different models of training and transfer of knowledge is discussed by a number of authors (Tudor, 2012, Singer and Moscovici, 2008).

The contribution of the use of system dynamics for modeling the costs when creating texts (management documentation) for the Human Resources division for a company working in an agribusiness sector is evaluated.

In this paper, the authors will try (using modeling approaches and the system dynamics) to clarify when and under what conditions it will be advantageous to use the knowledge-structured texts over normal texts. It means that the aim of the paper is to identify the differences in the costs of the company if the company working in an agribusiness sector had used documentation in the form of knowledge-structured texts as compared to conventional structure texts. Moreover, authors will try to determine from what point of time it is worthwhile, cost-wise, for the company to invest in the creation of guidelines in the form of knowledge-structured texts.

Materials and methods

The source of data

The model has been prepared for an unnamed company working in the sector of agriculture. The company is characterized as a medium-sized enterprise (MSE). The number of employees in last 5 years was between 172 and 237, the annual turnover of the company was about 300 million Czech crowns (CZK).

Data was used in the context of modeling the costs of creating guidelines, and only in the field of human resources (HR), especially in the areas of personnel processes of the back office, as this segment is responsible for the creation of the largest amounts of text documents (management documents) with powers not only for the Human Resources division, but also in other sections of the company, its sections and divisions. The directive that occurs in the HR back-office processes does not relate to each of the employees, i.e. it deals with the appropriate management of relevant sections, divisions etc. Then, it moves forward in the hierarchy within the organizational structure. For modeling the creation of guidelines and learning according to them, it is necessary to study the structure of employees, i.e. for which employee is the directive instruction manual intended. Data that has been obtained for the model (i.e. the value of external variables e.g. in terms of the number of employees, payroll, time allocated for the creation of texts, creation of reserves etc.) was provided for the purpose of the simulation by the director of the back-office section. About 70% of external variables and coefficients have real value, 30% of the variables were determined by an expert estimate, since these were the variables and factors that were not directly observed within the section and normally are monitored under a different aggregate variable, or some parameters were derived from experiments by Rauchová et al. (2013) Horáková and Houška (2014b), Rauchová and Houška (2013), Rauchová et al. (2014). The director of the section also provided expert consultations when drawing up the model in order to explain the relationships between variables in the process of making guidelines in a company focusing on agribusiness.

The knowledge unit and knowledge-structured texts

Knowledge-structured texts and normal texts as terms are distinguished in this paper. Houška and Rauchová (2013) proposed the methodology for creating the knowledge-structured text from a normal text, where the knowledge-structured text can also contain additional information on top of knowledge units (Dömeová et al., 2008) and standard production rules. At the same time, it was discovered that not all texts can be rewritten in the knowledge form. Knowledge-structured texts have been tested in the education process (Horáková and Rydval, 2015) as a possible tool for transferring the knowledge as compared to normal educational texts (Rauchová and Houška 2013a, Horáková and Houška 2014a), their efficiency of creation has been measured (Rauchová and Houška 2013b), and the quantitative profile of knowledge-structured text and its difference from text that is normal from the linguistic point of view has been determined statistically, too (Rauchová et al. 2014b, Horáková et al. 2015).

Knowledge-structured texts were tested in the educational process as a possible tool for knowledge transfer as compared to conventional educational texts (Rauchová and Houška, 2013). The efficiency of the production of knowledge-structured texts was measured as compared to normal texts (Rauchová and Houška 2013b), and time-consuming codification of knowledge-structured text creation was measured as well (Rauchová et al., 2013). Moreover, the quantitative profile of the knowledge-structured text and its difference from the normal text in terms of linguistics was observed as well (Rauchová et al., 2014b; Horáková and Houška, 2014b).

Utilization of knowledge in the agribusiness company for the management documents is the content of this paper that uses system dynamics for modeling the costs in the segment of the human resources section of the HR back-office processes during the development of guidelines in the common and knowledge-structured text form. The lifetime of texts depends on the number of organizational changes in the company and other changes related to the operation of the business. The results of the survey set the lifetime identically for both types of texts to 36 months (3 years). After reaching the end of the lifetime, new texts need to be created. The company covers the consequences arising from risks in the form of costs (contributing to the total cost). Consequences arising from risks can be prevented through well-processed texts and their subsequent use. Well-processed texts reduce costs needed to cover the results of risks, including the total cost.

Brief characteristic of system dynamics

System dynamics is a discipline that can be used to describe the modeling, simulation and analysis of dynamic complex problems (Forrester, 1999; Pruyt, 2013). The underlying idea is that the behavior of the system is significantly determined by its own structure, individual elements and relationships among them. System dynamics is currently applied in a wide range of so-called soft systems in the fields of economics, sociology, ecology, risk analysis, resource management and many other areas (Forrester, 1999; Sterman, 2000; Meadows, 2008; Mildeová and Vojtko, 2003; Mildeová, 2012).

The essence of understanding the system dynamics is that it works with dynamic systems whose behavior is directed by quantities varying in time (Meadows, 2008); the system must be understood as a deliberately defined set of elements and relationships among them, where bonds usually have informational character. Therefore, systems are designed for investigation in terms of system dynamics characterized by: 1/ dynamic complexity, 2/ feedback arrangement, 3/ time delay, 4/ adaptability, 5/ nonlinearity, 6/ interdependence.

System dynamics is used to improve the study and better understanding of complex systems. It may lead to creation of computer simulation models, managerial simulators, it helps to understand the complexity of the dynamics and, in particular, it helps to understand the implications of applied policies and serves for designing effective policies (Sterman, 2000). Politics, according to Forrester (1987), must be understood as a rule under which various decisions are made.

We define the system initially using a Casual Loop Diagram – CLD, and subsequently a Stock-Flow Diagram – SFD is created. CLD is an important tool for defining and representing the structure of feedback systems. CLD according to Sterman (2000) allows to: 1/ quickly record hypotheses about the causes of dynamics, 2/ obtain a mental model for individuals or groups, 3/ discuss important feedback that seems to be causing a problem. CLD consists of variables that are connected with oriented bonds which represent the influences of the variables. Polarity-oriented linkages show how the independent variable affects the dependent variable. Feedback loops are important for the behavior of systems. Feedback

can be either positive (self-intensifying, labeled with the "+" sign or the letter R that stands for Reinforcing), or negative (balancing, labeled with the "-" sign or the letter B that stands for Balancing). For larger loops, the feedback will be positive in the case of an even number of negative signs in the loop and negative in the case of an odd number of negative signs in the loop. CLD does not enable mathematical modeling of the system, but SFD does. More about CLD and SFD can be found in Sterman (1989, 2000) or Meadows (2008).

Results and discussion

The basic idea of reporting a problem

The model describes two alternatives, i.e. it monitors costs for the text documentation – company guidelines and directives. The first one describes the knowledge-structured text creation. The second one describes the same situation but with standard text creation. The costs are absolutely identical in some areas but they are different in other monitored areas. That is caused by the nature of the different structures of knowledge-structured texts and their different time consumption during the text creation (Rauchová et al., 2013) and also by a different difficulty of reading. On the other hand, people solving problems according to these specially-processed knowledge texts are able to solve tasks with higher accuracy as compared to normal text (Rauchová and Houška, 2013).

The model depicts costs for both types of texts – the costs of producing the text (in the knowledge-structured text form we have to describe costs of the knowledge engineer who helps codify the knowledge in the structure). The model also includes the costs of updating, i.e. modifications which occur when the average lifetime of text documents ends. The costs of the upgrade are also influenced by the experience with texts of that particular employee. Moreover, the model includes the learning curve coefficients. Furthermore, we are watching for example the average monthly number of pages (of directive documents) that are created, the intensity of changes in the text at the data, information and knowledge levels etc. Other parts of the model are the costs of learning using these texts, i.e. variables that influence learning are for example the average number of people who are learning the text directives, average time spent by reading the texts (with a higher coefficient of knowledge), the hourly wage of these employees etc. Again, these are utilized for the learning curve.

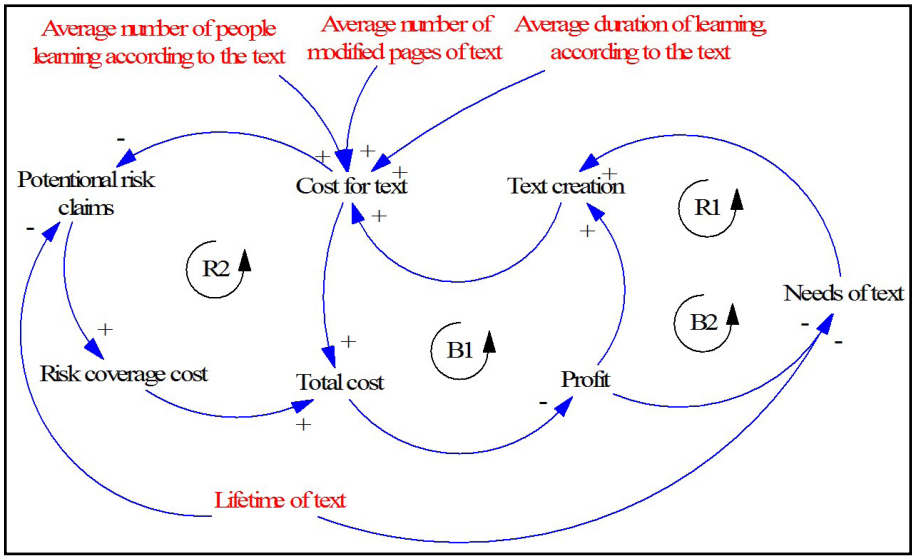
The company makes provisions each month to cover risks in the form of lawsuit court proceedings, fines and loss of business opportunities. From this point of view, it happens that a company using knowledge-structured texts faces a lower risk than with alternative conventional texts (Rauchová and Houška, 2013). At the same time, this risk decreases with the comprehensive restoration of the texts as a result of the end of lifetime of the management documents, and it increases when the documents are older. This relationship was linear for both alternative text forms created with graphics capabilities. It is also necessary to say that in the knowledge-structured texts, the reduction of the risk does not occur immediately but only after a certain delay when most employees are fully adapted to the change (Ross and Hulin, 1995).

In the model, there is also a variable which tracks the difference between these two alternatives. Other expenses (operation, overhead etc.) of the company are not included in the model, as it would be for the two alternatives that coincide. The goal is to model just their differences. The model also affects different delays in time, influence of experience (learning curve coefficients), non-linear relationship (plotted using graphical functions), feedback loop, polarity of relationships and more. The model is described using the first causal loop diagram (CLD) that reveals fundamental variables, feedback dishwasher and polarity of arrows, as well as the assembled diagram of stocks and flows, which can be used for monitoring flows, stocks (accumulation) and constants and also for watching purely external variables. The model was created in Vensim PLE (Ventana Systems Vensim Reference Manual, 2010).

CLD – Causal Loop Diagram

The CLD diagram in Figure 1 is composed of eleven variables; four variables (shown in red) are external variables that will be subject to the simulation, since they are tracking the costs and lifetime (service life) of important texts. The diagram consists of four feedback loops (R1, R2, B1, B2); two of them are reinforcing, denoted R1 and R2, and two are balancing, denoted B1 and B2. The graph also shows the polarity of relationships between different variables.

The feedback balancing loop **B1** shows the relationship between the costs and the creation of texts. ***Text creation*** influences the ***Cost for text***, which increases the ***Total cost*** that brings out lower ***Profit*** of the company. For lowering the costs, lower Profit causes lower ***Text creation***, resulting



Source: authors' own processing in Vensim

Figure 1: Causal loop diagram

in the decrease of the ***Cost for text*** and lower ***Total cost***.

Reinforcing feedback loop ***R1*** shows the following relationships between costs and needs of text. The more text is created, the higher the ***Cost for text*** and ***Total cost*** (including costs to cover the risk of lawsuits, legal proceedings and fines) are; this results in lower ***Profit of the company***. There are two ways to increase ***Profit***. Using the way of lowering the costs (displayed in balancing loop B1), the company can decrease the ***Text creation***, resulting in decreasing the ***Cost for text*** and, finally, ***Total cost***. The second way to decrease the ***Total cost*** is to try to improve the use of text and to increase ***Profit*** through the benefits of the use of text. Therefore, the lower the ***Profit*** is, the higher the ***Needs of text*** and ***Text creation*** are, resulting in lower potential risk of lawsuits, legal proceedings or fines and in more business opportunities, and therefore achieving higher ***Profit*** of the company.

The next feedback loops show the relationship between the creation of text and the potential risk claims. When a number of ***Potential risk claims*** is placed on the company, the ***Risk coverage cost*** increases, which results in higher ***Total cost*** of the company followed by the decrease of ***Profit of the company***. Then the company is at the same point with the same question: how to increase its ***Profit***. One way is to lower the costs (displayed in reinforcing loop ***R2***); the company can decrease the ***Text creation***, resulting in decreasing the ***Cost for text*** and, finally, the ***Potential risk claims*** are increased. This may be not so favorable for the company. The second way to increase ***Profit*** is to try to improve the use of the text and to decrease the ***Cost*** and achieve higher ***Profit*** through the benefits of the use of the text (lower potential risk of lawsuits, legal proceedings or fines, and more business opportunities). Therefore, the lower the ***Profit*** is, the higher the ***Needs of text*** and ***Text creation*** are, followed by an increase of the ***Cost for text*** and resulting in lower ***Potential risk claims***.

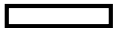
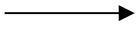
SFD – Stock and Flow Diagram

The above-mentioned model is also depicted in the stock and flow diagram in Figure 2.

Basic building blocks used in system dynamics and in the SFD model with icons are shown in the table below, adapted from Fowler (2003), Meadows (2008), Mildeová (2011).

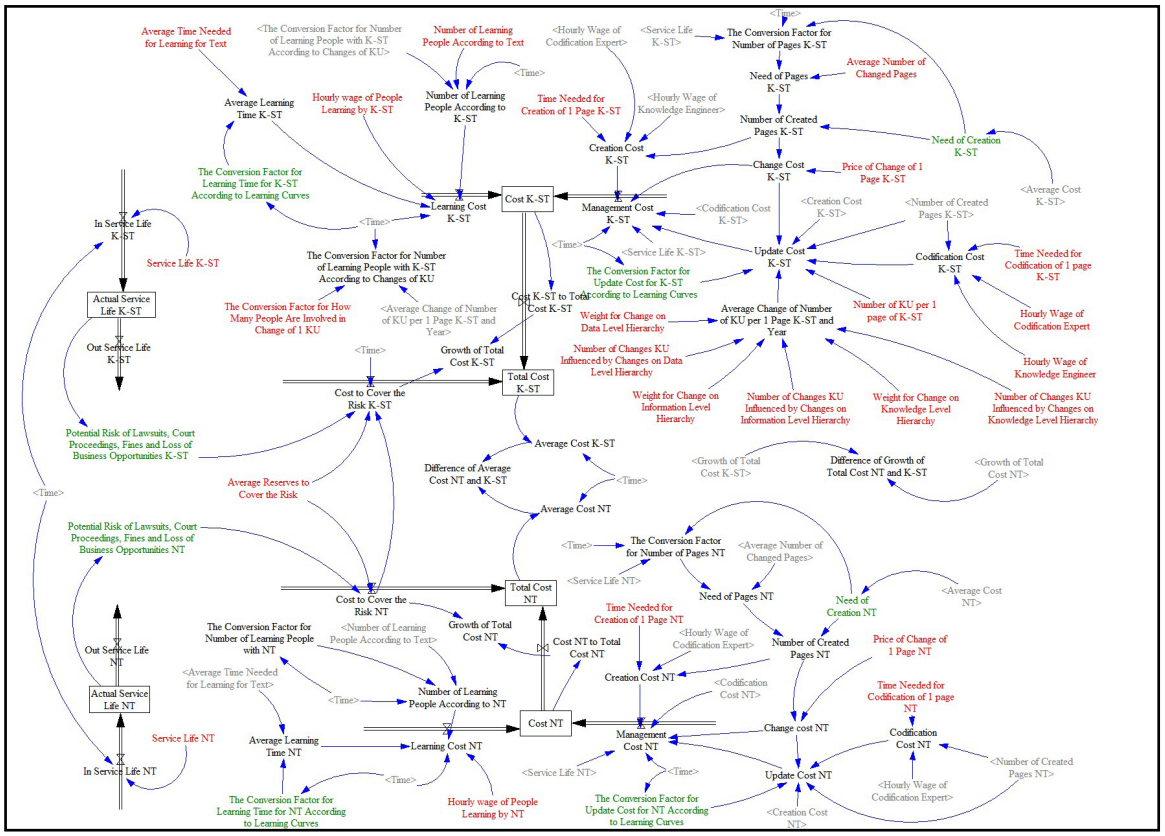
The model of creating management documents displayed in the stock and flow diagram (Figure 2) can be divided into three main parts. The left part shows the lifetime of texts. The ***Lifetime of text*** (in the SDF model as *Service Life NT* and *Service Life K-ST*) is a very important variable because it influences the level of the ***Cost to Cover the Risk***. We can suppose that with high actuality and long lifetime of the texts, we can prevent the ***Potential risk claim***s, and therefore decrease the ***Cost to Cover the Risk*** included in ***Total cost***.

The model of creating management documents displayed in the stock and flow diagram (Figure 2) can be divided into three main parts. The left part shows the lifetime of texts. ***Lifetime of text***

Building block	Symbol	Description
Stock (level)		Shows an accumulation of any variable.
Flow (rate)		Attached to a stock. Alters stock level by an inflow or an outflow.
Auxiliary (convertor)	Without symbol	Connects a stock and a flow in a complex setting. Used for intermediate calculations.
Connector (arrow)		Links different building blocks, showing the causality.

Source: authors' own processing

Table 1: Basic building blocks.



Source: authors' own processing in Vensim

Figure 2: Stock and flow diagram.

(in the SDF model as *Service Life NT* and *Service Life K-ST*) is a very important variable because it influences the level of the ***Cost to Cover the Risk***. We can suppose that with high actuality and long lifetime of the texts, we can prevent the ***Potential risk claims***, and therefore decrease the ***Cost to Cover the Risk*** included in ***Total cost***.

The top part of the model displays the process and variables affecting the knowledge-structured text creation. There are many variables representing the variable costs occurring by the text creation, such as ***Creation Cost K-ST, Change Cost K-ST, Update Cost K-ST, Codification Cost KS-T, Management Cost K-ST,*** and other variables, for example ***Number of Created Pages K-ST, Need of Creation KS-T, Learning Cost K-ST***.

The bottom part of the model displays the process and variables occurring in relation to normal text creation. In this part of the model, there are variables, such as ***Creation Cost NT, Change Cost NT, Update Cost NT, Codification Cost NT, Management Cost NT,*** and other variables, ***for example Number of Created Pages NT, Need of Creation NT, Learning Cost NT.***

The top and bottom parts (the part of the knowledge-structured and normal text) are very similar but they differ in variables that occur resulting from different text creation processes. In the knowledge-structured text creation process, the knowledge engineer who helps codify the knowledge-structured text in the structure is needed. Therefore, in this process the new variable, for example ***Hourly Wage***

of Knowledge Engineer, occurs.

In the middle part of the model, the output variable is created, i.e. ***Average Cost K-ST, Average Cost NT, Difference of Average Cost NT*** and ***K-ST***.

Research questions

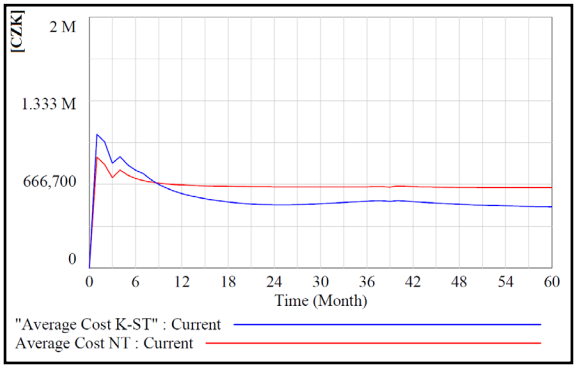
The following is a list of research questions that we will answer using model outputs after simulation.

- From what point in time is the average total cost of the company (i.e. its selected section) using the knowledge-structured texts in the management documents lower than for companies using regular texts (for equally long test period)?
- What is the evolution of the average total cost of the company (i.e. selected section of the company) using the knowledge-structured and normal text in the management documents?
- Are the knowledge-structured texts worth introducing in a small- or medium-sized company working in the sector of agriculture?

The important variables influencing management and data, information and knowledge processing at the company level are:

- Average number of modified pages [number of pages / month]
- Average number of people learning using the text [number of people / month]
- Average time of learning based on the text [hour / month]
- Average costs to cover risks [CZK]
- Lifetime (service life) of normal text [month]
- Lifetime (service life) of knowledge-structured text [month]

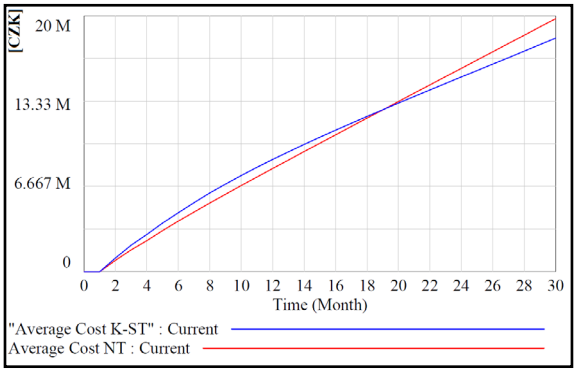
The answer to the first question of the research is given by the graph in Figure 3, which shows the average total cost in the sector of companies working with management documentation in normal form (i.e. using normal/common texts - NT) with the red curve, and the expense of the section of the company that is processing management documentation using models knowledge units (i.e. using knowledge-structured texts – K-ST) with the blue curve. If we project the intersection of the two curves to the x-axis (showing the time in months), it is clear that from the 9th month, the costs of NT are higher than those of K-ST; this is caused by a decrease of the average total cost for the segment using NT. That was caused by the adaptation of workers to change the structure of the management documentation and a decrease in the risk of lawsuits, causing a significant reduction in the costs of the risk coverage (as reserves).



Source: authors' own processing in Vensim

Figure 3: Average Cost of K-ST and NT.

The graph below (Figure 4) shows the accumulation of monthly costs and it is apparent that the cumulative amount of monthly costs for a company using NT will begin exceeding the cumulative amount of the monthly expenses of the company using K-ST in the 19th month. This means that after 19 months, the company using K-ST under otherwise identical conditions will become more profitable as compared to a company using NT. From the 9th month to the 19th month, the company using K-ST offsets the loss caused by introducing K-ST and employee training as compared to companies using NT.



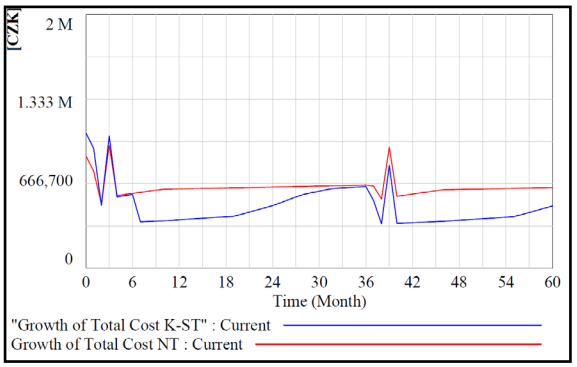
Source: authors' own processing in Vensim

Figure 4: Cumulative average cost of K-ST and NT.

Figure 5 shows the increase in total costs, which are (in order to simplify the model, as shown above), generated only by costs arising from the need to cover potential risks and by costs resulting from the use of texts. As the graph shows, the costs of the company using K-ST increase in the first months after the introduction of K-ST faster than the monthly costs of companies using NT. This is caused by the fact that the company using K-ST in the first months after the introduction of K-ST is also using NT at the same time, and it

ceases to use NT and uses only K-ST as late as after the development of K-ST and training of personnel. In this case study, monthly costs begin to decrease not sooner than after 6 months, mainly because of lower costs of the risk coverage, which is the most significant benefit arising from K-ST.

The increase of the monthly costs is mainly influenced by the service life of the texts. Texts have a lifetime of about 3 years (36 months). After they reach the end of their lifetime, it is necessary to create new texts in the extent required by the company.



Source: authors' own processing in Vensim

Figure 5: Increase of total costs of K-ST and NT.

The following graph (Figure 6) shows the difference in average monthly costs of companies using normal texts (NT) and the one using the knowledge-structured texts (ST-K). The resulting difference is calculated by subtracting the average monthly costs of companies using K-ST from average monthly costs of the company using NT.

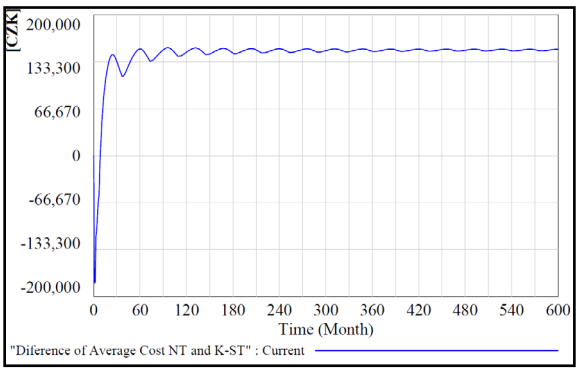


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Figure 6: Difference of average costs K-ST and NT.

It is evident that in the long run, the company using NT has higher average monthly costs (the difference shifts to positive values). Therefore, it can be stated that although the costs of the initial introduction of K-ST are higher than NT, due to the benefits derived from K-ST (e.g. reducing costs to cover risks as shown above) the reduction of the monthly expenses is achieved.

The conclusions mentioned above indicate that this case study has demonstrated that the introduction and use of corporate documentation in the form of structured knowledge is beneficial for the company in the sector of agriculture in terms of monitored economic indicators.

Conclusion

The results show that the investment needed to adapt management documents in the form of knowledge-structured texts is worthwhile for a mid-size company focused on agribusiness, and especially for large companies and corporations with an extensive organizational structure, i.e. companies with a high number of management documents. However, the question is how the various parameters are to be set. Furthermore, it has to be assumed that an important role is played by the regular development of the company and that extensive organizational changes, which were (at a simulated section of the company) set for 3 years, referred to as the life directives, in the intervals between thorough editing only occur in order to update the guidelines, with varying intensity and weight changes at the level of the texts in the hierarchy of data, information and knowledge. For the simulation, a range of Human Resource Management processes of the back office of the selected agribusiness company was chosen. It is involved in the development of guidelines that are used to control the entire organizational structure of the company and cover only 10% of all employees (executives) as well as other employees in the typical positions of specialists, experts etc., and ultimately affect (directly or indirectly) the activities of people working in the operation of the selected organization. For existing parameters set by the above-mentioned section in any investment in knowledge management documents, the costs fall below the level of the current costs between the 15th month (optimistic estimate) and the 20th month (pessimistic estimate).

There are other variables that have an impact on costs, for example the ability of workers to adapt to change (not only from the point of view of the content of the text) as well as to get used to a different structure of the text, employee turnover and the number of reserves that the company generates in order to cover risks arising from non-observance or violation of the transcripts of the management documentation. There is especially a risk in the form of lawsuits, legal proceedings, fines and loss of business opportunities.

In future, the effort of authors is to generalize the above-mentioned model. It could be used for other businesses or extended, for example, in the area of yields and monitoring of economic efficiency of investment management documentation in the form of knowledge of texts. It can be also used to support the possible emergence of a new business offering outsourcing services for editing the management documentation (for larger companies), or offering courses of text editing in the knowledge form (for smaller companies).

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