ISSN 2080-7279
2014 Volume 06 Number 02

foundations of management 2/2014

INTERNATIONAL JOURNAL

fom

WARSAW UNIVERSITY OF TECHNOLOGY
FACULTY OF MANAGEMENT

Foundations of Management

Editor-in-Chief

Tadeusz KRUPA

Faculty of Management
Warsaw University of Technology, Poland
e-mail: t.krupa@wz.pw.edu.pl

Frequency

Published four issues per year
three regular and one special issues prepared by invited editors

Internet

The International Journal - Foundations of Management
is currently available on-line at:
http://www.fom.pw.edu.pl/s110/foundations-of-management
http://bcpw.bg.pw.edu.pl/dlibra
http://www.degruyter.com/view/j/fman

Publishing and Editorial Office

Faculty of Management, Warsaw University of Technology
ul. Narbutta 85, 02-524 Warszawa, Poland
e-mail: t.krupa@wz.pw.edu.pl
tel.: +48 22 849 94 43, 22 234 84 32
fax: +48 22 849 97 98

Scientific Editor

Teresa Ostrowska
e-mail: t.ostrowska@wz.pw.edu.pl

Cover Project and Print

Warsaw University of Technology Publishing House
ul. Polna 50, 00-644 Warszawa
tel.: +48 22 234-70-83
fax: +48 22 234-70-60

ISSN 2080-7279

Ladies and Gentlemen,

Foundation of Management (FoM) journal was established at the Faculty of Management at Warsaw University of Technology in order to provide an international platform of thought and scientific concepts exchange in the field of managerial sciences.

This new publishing forum aims at the construction of synergic relations between the two parallel trends in managerial sciences: social and economical – originating from economic universities and academies and the engineering trend – originating in from factories and technical universities.

Three of the great representatives of the engineering trend in managerial sciences - American Frederic W. Taylor (1856-1915) – developer of high speed steel technology and the founder of the technical with physiological trend in scientific management, Frenchman Henri Fayol (1841-1925), the author of basics of management and the division and concentration of work as well as the Pole Karol Adamiecki (1866-1933) graduate of the Saint Petersburg Polytechnic University and the professor of Warsaw University of Technology, creator of the time-scale system elements scheduling theory and diagrammatic method as well as the basics of the division of work and specialization – have, on the break of the XIX and XX century, all created the universal foundations of the management sciences. Therefore the title of the Foundation of Management is the origin of the scientific and educational message of the journal that is aimed at young scientists and practitioners – graduates of technical and economic universities working in different parts of Europe and World.

The target of the establishers of the Foundation of Management journal is that it will gradually increase its influence over the subjects directly linked with the issues of manufacturing and servicing enterprises. Preferred topics concern mainly: organizational issues, informational and technological innovations, production development, financial, economical and quality issues, safety, knowledge and working environment – both in the internal understanding of the enterprise as well as its business environment.

Dear Readers, Authors and Friends of the Foundation of Management – our wish is the interdisciplinary perception and interpretation of economic phenomena that accompany the managers and enterprises in their daily work, in order to make them more efficient, safe and economic for suppliers and receivers of the products and services in the global world of technological innovation, domination of knowledge, changes of the value of money and constant market game between demand and supply, future and past.

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The Guardian of the journal's mission is its Programme Committee, which participants of which will adapt to current trends and as an answer to the changing economic and social challenges in the integrating Europe and World.

Tadeusz Krupa

CONTENTS

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Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0007

ESTIMATING NEW PRODUCT SUCCESS WITH THE USE OF INTELLIGENT SYSTEMS

Marcin RELICH*, Krzysztof BZDYRA**

*Faculty of Economics and Management, University of Zielona Góra, Zielona Góra, Poland
e-mail: m.relich@wez.uz.zgora.pl

**Faculty of Electronic and Computer Engineering, Koszalin University of Technology, Koszalin, Poland
e-mail: krzysztof.bzdyra@tu.koszalin.pl

Abstract: The paper presents identifying success factors in new product development and selecting new product portfolio. The critical success factors are identified on the basis of an enterprise system, including the fields of project management, marketing and customer's comments concerning the previous products. The model of measuring the success of a product includes the indicators such as duration and cost of product development, and net profit from a product. The proposed methodology is based on identification of the relationships between product success and project environment parameters with the use of artificial neural networks and fuzzy neural system that is compared with the results from linear model. The presented method contains the stages of knowledge discovery process such as data selection, data preprocessing, and data mining in the context of an enterprise resource planning system database. The illustrative example enhances a performance comparison of intelligent systems in the context of data preprocessing.

Keywords: project management, new product development, knowledge acquisition, data mining, ERP system.

1 Introduction

New product development (NPD) is one of the most important processes in maintaining a company's competitive position and continuing business success. New products and innovations impact on sales volume, employment, technological process, and economic progress. Contribution of NPD to the growth of the companies, its influence on profit performance, and its role as a key factor in business planning has been widely considered [e.g. 1-3]. Nevertheless, it is still reported that the success rate of product development projects is unsatisfactory, with more cost and time than expected having been consumed to achieve the project goals.

The main reasons why most companies have failed in the development of new products derive from extrinsic and intrinsic problems. Extrinsic problems include flops in the market, changes in regulations or simply competition develops product first [4]. Intrinsic problems concern the limited resource constraints (e.g. temporal, financial, and human) and result in the difficulties to meet the project goals, including product innovativeness. Unsatisfactory success rate of product development projects can also be considered from the perspective of inherent feature of NPD, that is, it is a relatively risky activity [5], as market competition and product technology advancement are often intense [6].

Although the success of a new product depends on the environmental uncertainties that are beyond a firm's control, companies should take into account both external and internal indices that can impact on the product success. Internal indices can be acquired from company's databases, including Enterprise Resource Planning (ERP) system, project management software, customer relationship management system, etc.

The proper choice of critical success factors and metrics can improve the accuracy of new product evaluation, determine an optimal set of new products for development, more effectively use the company's resources, and finally reduce an unnecessary cost. A key challenge faced by new product development projects is how to acquire knowledge, sustain success rate among the products, and manage the project in order to reduce the risk of failure of the product [4].

This study aims to develop an approach that identifies the relationships between the success of a product and the key factors that are stored in an enterprise information system and that influence on this success.

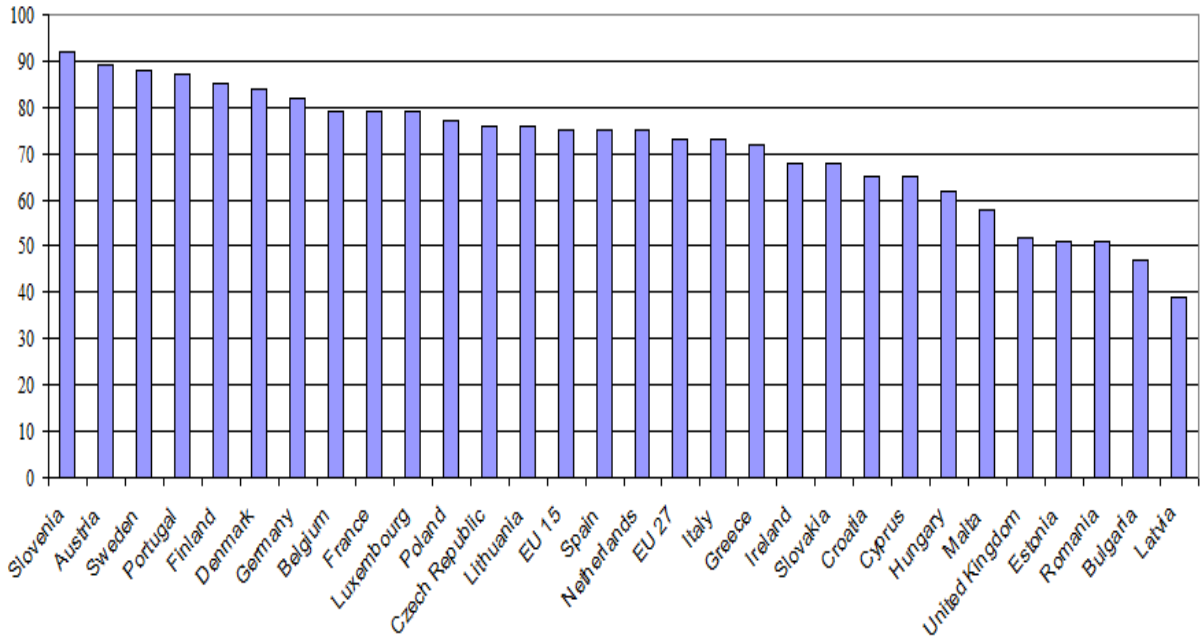

Figure 1. Use of ERP software in large enterprises in the EU countries in 2013 (in %) (*source: [10]*)

This approach takes into account data of the previous projects that can be retrieved from an ERP system, including the fields such as marketing and sales, production, project management and the customers' complains. The identification of patterns from an ERP database uses computational intelligence techniques, such as the artificial neural networks and fuzzy neural system. The sought relationships are used for estimating the success rate of the products that are considered for development, and proposing such changes in project environment that can increase the chance to develop a successful product. The set of potential products for development is determined with the use of integer programming taking into account the company's constraints.

The novelty of this research concerns the proposed model of measuring product success that is adjusted to the structure of an ERP system. The proposed approach has several advantages such as the low effort of data retrieval (the data are accessible in an ERP system) and creating new ideas for product development on the basis of customers' complaints, requirements, comments that are registered in an ERP system. The proposed methodology is based on computational intelligence techniques that enable pattern recognition in the large databases but also require preprocessing of data. Therefore, the aspect of data preprocessing is enhanced in this study.

The remaining sections of this paper are organized as follows: section 2 presents the literature review regarding enterprise resource planning systems and measurement of product success. A model of measuring product success with the use of an ERP database is presented in section 3. The proposed method of product portfolio selection is shown in section 4. An example of the proposed approach, which includes a comparison between intelligent systems and linear model for estimating the success of a product, is illustrated in section 5. Finally, some concluding remarks are contained in section 6.

2 Literature review

2.1 Enterprise resource planning systems

In recent years, the advancement of information technology in business management processes has placed ERP system as one of the most widely implemented business software in various enterprises. ERP systems help to collect, operate, and store data connected with the daily business processes in an enterprise (e.g. customer orders, goods receipts) [7-9]. The use of an ERP system is especially widespread in the large- and medium-sized enterprises (see Fig. 1 and Fig. 2), where the enormous number of business processes appears.

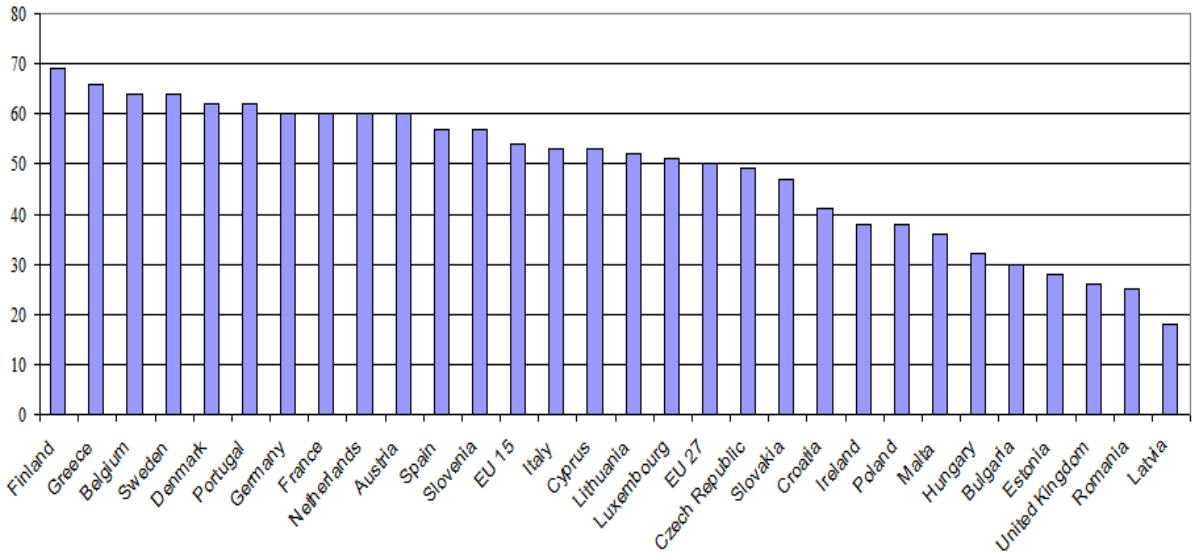

Figure 2. Use of ERP software in medium enterprises in the EU countries in 2013 (in %) (*source: [10]*)

An ERP system is an integrated information technology (IT) that uses common databases and consistent cross-functional information flow to allow companies to integrate information from different departments and locations [11]. The primary task of an integrated system is to maintain the data flow of an organization and to reduce the redundancy [12-13]. An ERP system can also be considered as the seamless integration of all the information flowing through the company such as finances, accounting, human resources, supply chain, and customer information [14]. Main objectives for an ERP system implementation are connected with maximization of business process effectiveness, data analysis, system use, organizational IT competence, productive working relationships, information richness and security, as well as minimization of information dispersion. These objectives aim to minimize cost and maximize customer relationship effectiveness, and product and services improvement [13].

New product development process can be supported by project management software in the form of an alone IT tool (e.g. Microsoft Project) [15-16] or an integrated approach such as an ERP system [8-9]. In the case of new products that are only small-scale modifications, there is possibility to use the past project parameters and other ERP attributes (e.g. marketing cost, production cost, customer complaints) in order to seek the relationships among the data. These relationships aim at improving estimation quality for duration and cost of new product development, and the success of a product.

2.2 Measurement of product success

The definition of a successful project is in the various ways considered in the literature [e.g. 17-19]. As measuring criteria, the fulfillment of a fixed goal, the compliance with budget progress, or achieving an acceptable level of performance were used in past studies. Pinto and Mantel identified three aspects of project performance as benchmarks for measuring the success or failure of a project: the implementation process, the perceived value of the project, and client satisfaction with the final product [20]. Freeman and Beale identified seven main criteria to measure projects success: technical performance, efficiency of execution, managerial and organizational implications (mainly customer satisfaction), personal growth and a manufacturer's ability, business performance, project termination, and technical innovativeness [21]. Cooper and Kleinschmidt presented the multidimensional nature of NPD performance with 10 measures [22]: success rate, percent of sales, profitability relative to spending, technical success rating, sales impact, profit impact, success in meeting sales objectives, success in meeting profit objectives, profitability relative to competitors, and overall success.

Lipovetsky *et al*. defined four dimensions for measuring the success of various projects [23]: meeting design goals, benefits to the customer, benefits to the developing organization, and benefits to the defense and national infrastructure.

Table 1. The criteria for measuring product success
(*source: [19–25]*)

Authors	**Criteria**
Pinto and Mantel (1990)	The implementation process The perceived value of the project Client satisfaction with the final product
Freeman and Beale (1992)	Technical performance Efficiency of execution Managerial and organizational implications Personal growth and a manufacturer's ability Business performance Project termination Technical innovativeness
Cooper and Kleinschmidt (1995)	Success rate Percent of sales Profitability relative to spending Technical success rating Sales impact Profit impact Success in meeting sales objectives, success in meeting profit objectives, profitability relative to competitors, overall success
Lipovetsky *et al*. (1997)	Meeting design goals Benefits to the customer Benefits to the developing organization Benefits to the defense and national infrastructure
Sounder and Song (1997)	Sales Market share Return on investment Profit Customer satisfaction Contribution to technology leadership Contribution to market leadership
Sun and Wing (2005)	Clearly defined target market Implementation of quality standards, clear project goal, consider issues at early stage Internal communication within the project team Delivery of new product to customers on time, right time to launch, competitive product cost

Table 1 (cont.). The criteria for measuring product success
(*source: [19–25]*)

Wei *et al*. (2008)	Proficiency of pre-development Proficiency of the whole process Proficiency of scheme Proficiency of development Proficiency of market launch

Sounder and Song proposed seven criteria in making overall judgments about the new product development in the context of actual performance versus the original expectations [24]: sales, market share, return on investment, profit, customer satisfaction, contribution to technology leadership, and contribution to market leadership. Sun and Wing identified the product success with clearly defined target market, project goal, internal communication, right time to launch, and competitive product cost [19]. In turn, Wei *et al*. considered the new product development (NPD) project success as the proficiency of pre-development, scheme (the well-defined new product performance and NPD project target), whole process, development, and market launch [25]. Table 1 presents the different approaches for evaluating the success of a project.

New product development is a complicated and time-consuming process in which several different activities are involved. Sun and Wing presented the NPD process in the context of the following phases: ideas generation and conceptual design, definition and specification, prototype and development, and commercialization [19]. In turn, Cooper and Kleinschmidt presented four main aspects of NPD process which bring positive influences for NPD project success [22]: the clear definition of product before development begins (including product concept and target market), the high quality preparatory work (including the detailed technical and market-oriented feasibility studies, and a commercial evaluation of the NPD project), the clear orientation of NPD process to market (including market research activity and competition observation), and the existence of a high quality NPD process control. All these aspects are critical for the NPD project success; however, the focus on the early phases of NPD project can reduce the cost in the further phases.

Literature review on the product success metrics summarized in Table 1 shows that most of the proposed approaches are based on the evaluation of multiple criteria. From the company perspective, it is especially important to determine such critical success factors that can be retrieved from an internal database and that enable the decision to terminate the unpromising projects before the beginning of the NPD process. In this study, measuring the success of a product is based on quantitative criteria concerning marketing, production and project performance for which data is stored in an ERP system. The issue of the data retrieval from an enterprise system to evaluate a NPD process is neglected in the above approaches. This is the motivation to develop a model of measuring the success of a product that is based on an ERP database.

3 Model of measuring product success on the basis of an ERP database

The enterprise systems generate routinely an enormous amount of data according to the business processes in a company. As the amount of available data in companies becomes greater and greater, companies have become aware of an opportunity to derive valuable information from their databases, which can then be used to improve their business [26]. The process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data is known as knowledge discovery [27]. The knowledge discovery process includes the stages such as data selection, data preprocessing, data transformation, data mining, and interpretation (evaluation) of the patterns identified [9, 27].

Analysis of the data and knowledge acquisition with the use of manual methods is slow, expensive, subjective, and prone to errors. Hence, there is a need to automate the process through using data mining techniques. The most commonly used tasks in data mining include classification, clustering, associations, visualization, summarization, deviation detection, link analysis, and estimation that is further considered.

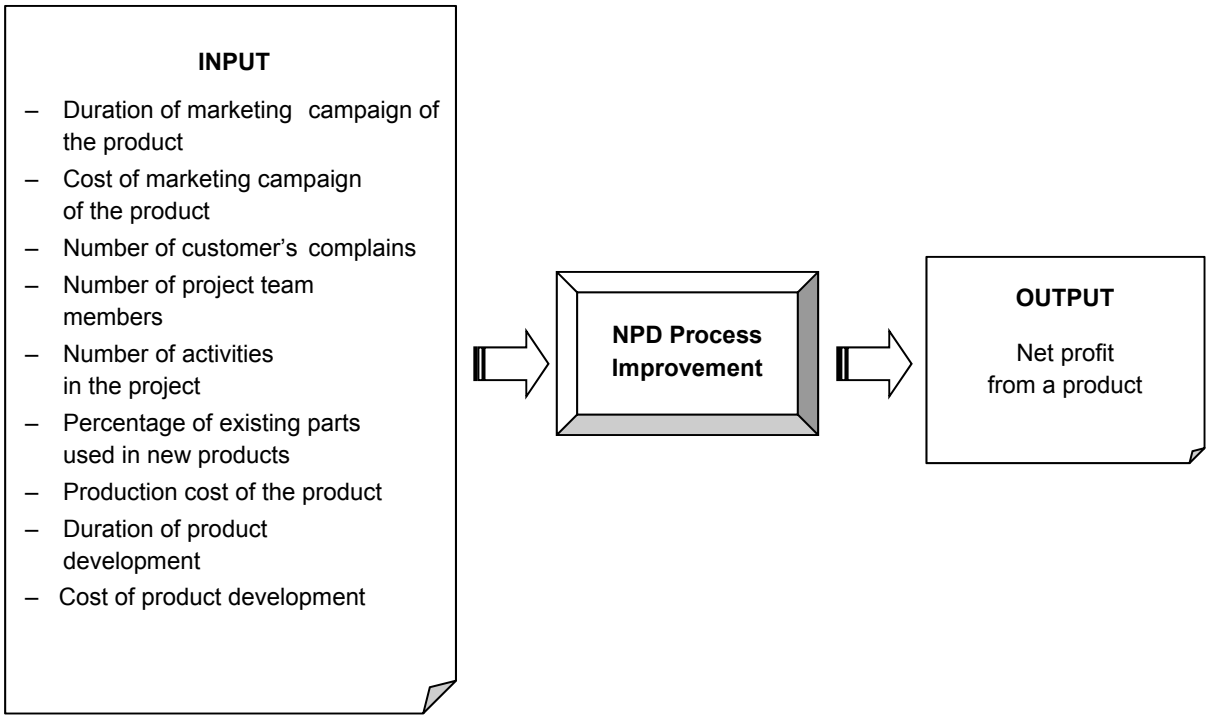

Figure 3. Input–output system of NPD process improvement (*source: own elaboration*)

The proposed model consists of variable that describes the product's success (output data) and variables that are suspected of having a significant impact on this success (input data). The model has been elaborated on the basis of the previous studies that included observation of successful companies and confrontation with literature (see Table 1), as well as from the perspective of data stored in an enterprise system (e.g. ERP and CRM[1] system, project management software).

The success of a product can be measured in profit growth, export rate, success rate of new products, market share, etc. Taking into account the product lifetime and return on product development expense, as the output variable and the measure of the product success, the average net profit from a product per month is chosen. In turn, the input variables are classified into the fields such as marketing, customer, project management, and finance. Performance indicators (input variables) for marketing perspective include duration of marketing campaign of the product and cost of marketing campaign of the product; for customer perspective - number of customer's complains (requirements, comments) for the previous products that have been used to developing a new product; for project management perspective - number of employees who directly develop a new product (project team members), number of activities in the project, percentage of existing parts used in new products; for finance perspective - production cost of the product. These variables can be retrieved from an enterprise system database. Figure 3 presents input–output system for measuring the success of a product, and consequently, for improving the NPD process.

The presented model is based on the assumptions such as access to data of past successful and unsuccessful NPD projects, including their cost, duration, team members, and current market position of a product. The model enables the identification of relationships between the success of new product and the key factors in the field of project management that influence on this success, and it can be considered in terms of learning from the past experiences to improve the success of products in the development process.

[1] Customer Relationship Management, denoting strategies and software that enable a company to organize and optimize its customer relations.

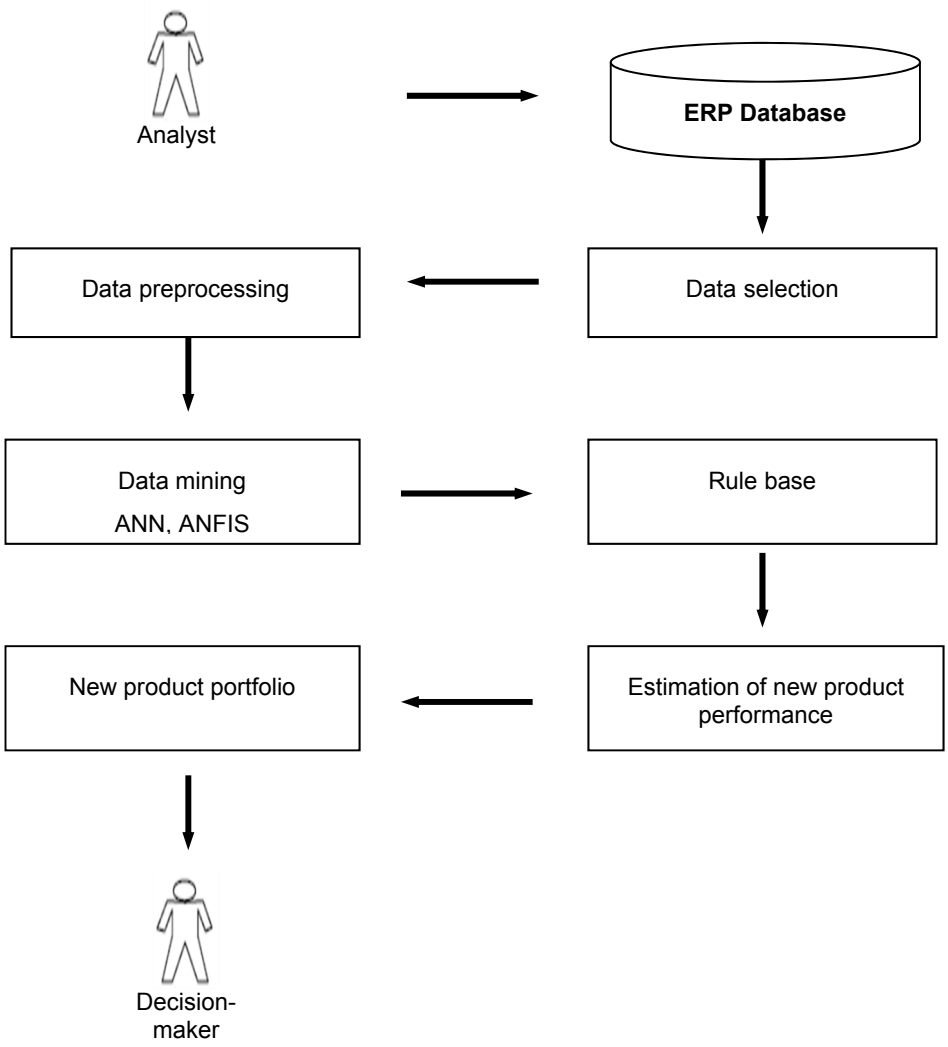

Figure 4. Framework of product portfolio selection
(*source: own elaboration*)

The solution of the considered problem includes seeking answers to the following questions: is there a significant relationship between the marketing and project management parameters and the success of a product? Are accessible resources in company to improve the effectiveness of project management, and finally, the success rate? What parameters should have the current projects to increase their chances for the success? What is a set of input variables that impacts the strongest on the output variable?

The sought relationships can indicate the directions of improvement of products that are in the development process and, as a result, increase the chance to develop a successful product and support the success rate from new products in a company. The pattern identification from an ERP database requires using the specific knowledge discovery methods that are adjusted to the characteristics of an ERP system. A method for seeking the relationships among ERP parameters, selecting new product portfolio, and obtaining the answers to the above questions is presented in the next section.

4 Method for product portfolio identification

The method consists of the following phases: data selection from an ERP database by analysts, data preprocessing, data mining and identification of patterns (rule base) with the use of the artificial neural networks (ANN) and the adaptive neuro-fuzzy inference system (ANFIS), and selection of the most promising new products to the project portfolio. Figure 4 illustrates the phases of the proposed method.

The use of ANN and ANFIS requires preprocessing the data that is retrieved from ERP systems [28–30]. One of the feature reduction methods is principal component analysis (PCA) that reduces the dimension for linearly mapping high dimensional data onto a lower dimension with minimal loss of information. Data preprocessing has been performed with the use of PCA that is the best, in the mean-square error sense, linear dimension reduction technique [31]. In the next step, the relationships among the chosen variables are sought with the use of ANN and fuzzy neural system.

Pattern discovery from databases requires some data mining techniques that cope with the description of relationships among data and that solve the problems connected with, for example, classification, regression, and clustering. These techniques include neural networks, fuzzy sets, rough sets, time series analysis, Bayesian networks, decision trees, evolutionary programming and genetic algorithms, etc. The ANN and fuzzy logic are complementary technologies and powerful design techniques that can be used in the identification of patterns from within a large database and noisy data that is common for an ERP system.

ANN are an important class of tools for quantitative modeling. Nowadays, ANN are treated as a standard data mining tool and used for many data mining tasks such as pattern classification, time series analysis, prediction, and clustering. Neural networks are computing models for information processing and are particularly useful for identifying the fundamental relationship among a set of variables or patterns in the data. The popularity of neural networks is due to their powerful modeling capability for pattern recognition. Among characteristics of ANN that make them suitable and valuable for data mining are the lack of several unrealistic a priori assumptions about the underlying data generating process and specific model structures, nonlinearity of ANN models, ability of solving problems that have imprecise patterns or data containing incomplete and noisy information with a large number of variables. This fault tolerance feature is appealing for data mining problems because real data is usually noisy and does not follow clear probability structures, which are typically required by statistical models [32].

The fuzzy neural system has the advantages of both neural networks (e.g. learning abilities, optimization abilities and connectionist structures) and fuzzy systems (simplicity of incorporating expert knowledge). As a result, it is possible to bring the low-level learning and computational power of neural networks into fuzzy systems and also high-level human like IF–THEN thinking and reasoning of fuzzy systems into neural networks. The behavior of a fuzzy neural system can be represented by a set of humanly understandable rules or by a combination of localized basis functions associated with local models, making them an ideal framework to perform nonlinear predictive modeling [33]. One well-known structure is the ANFIS that enables the nonlinear modeling, simulation, and forecasting.

The success of a product is estimated with the use of the relationships identified (rule base) and further used to select the most promising products for development. This product portfolio takes into account the constraints (financial, temporal, personal, etc.) and can be determined with the use of the constraint programming [34–39]. In the process of choosing the optimal product portfolio, the decision maker can be involved through the weights preferred for the criteria considered. The next section presents an example of the use of the proposed approach to identify net profit value for products and select the optimal product portfolio for development.

5 Illustrative example

The illustrative example consists of three parts that refer to the presented methodology:

- description of the variables used to carry out the analysis,
- identification of the relationships between input variables and the success of a product,
- determination of the optimal product portfolio for the development process.

5.1 Description of the variables used in the example

The output variable is net profit from a product that is treated as a measure of product success. The input variables concern the fields of marketing, project management, research and development (R&D), and production that can be retrieved from an enterprise's internal database, for instance, an ERP system.

Table 2. Planned values of input variables for new product projects
(*source: own elaboration*)

Input variable	P1	P2	P3	P4
I1	26	19	33	37
I2	86	68	102	115
I3	25	13	29	32
I4	9	4	7	12
I5	60	35	71	84
I6	0.45	0.67	0.34	0.25
I7	0.14	0.21	0.39	0.59
I8	26	15	29	36
I9	54	27	69	78

Taking into account the literature review of measuring product success, the following input variables have been chosen:

- period of marketing campaign of the product (I1),
- cost of marketing campaign of the product (I2),
- number of customer's complaints for the previous products that have been used to develop a new product (I3),
- number of employees who directly develop a new product (I4),
- number of activities in the NPD project (I5),
- percentage of existing parts used in a new product (I6),
- unit cost of production for the product (I7),
- period of product development (I8),

cost of product development (I9).The success of new product is estimated on the basis of the parameters of the previous NPD projects. There are sought the relationships between the above-described input variables and net profit from a product. Moreover, some input variables can be used to estimate the period of product development {I3, I4, I5, I6}, and the cost of product development {I3, I4, I5, I6, I8}. Let us assume that the initial project portfolio includes the development of four products {P1, P2, P3, P4}. The project resources such as employees in R&D department and project portfolio budget are limited to 21 people and 148 monetary units. Table 2 presents the planned values of input variables for new products that are considered for the development process.

5.2 Identification of relationships

The identification of relationships between the input variables and net profit from a product has been sought with the use of intelligent systems such as the ANFIS and ANN. In order to eliminate the overtraining of ANFIS and ANN (too strict function adjustment to data) and to increase the estimation quality, the data set has been divided into learning (P1–P25) and testing sets (P26–P32).

The results have been calculated in the Matlab® software and presented in Table 3 as the root mean square errors (RMSE) for the learning and testing set. The results for ANFIS and ANN are compared with the average and linear model that is determined according to the ordinary least squares method.

In studies, a multilayer feed-forward neural network was trained according to the back-propagation algorithm. Weights were optimized according to the Levenberg–Marquardt algorithm (LM) and gradient descent momentum with adaptive learning rate algorithm (GDX). The neural network structure was determined in an experimental way, by the comparison of learning and testing sets for the different number of layers and hidden neurons.

The RMSE was calculated as the average of 20 iterations for each structure of neural network with a number to the extent of 20 hidden neurons.

Table 3. Comparison of RMSE for different models
(*source: own elaboration*)

Model	Without preprocessing		With preprocessing	
	Learning set	**Testing set**	**Learning set**	**Testing set**
ANN – GDX	70.22	67.77	26.40	24.22
ANN – LM	45.79	43.41	9e–12	33.84
ANFIS – hybrid	32.41	29.14	0.0004	27.14
ANFIS – backprop (100 iterations)	35.89	27.46	0.407	26.98
ANFIS – backprop (1000 iterations)	35.14	27.20	0.396	26.85
Linear model	21.16	30.91	21.16	30.91
Average	70.22	67.31	70.22	67.31

In turn, ANFIS was trained according to subtractive clustering method by the use of the back-propagation and hybrid algorithm. After learning phase, the testing data was led to input of the fuzzy neural system to compare the RMSE for ANFIS and other models.

Table 3 presents the RMSE in the learning and testing set for the different models in the aspect of data preprocessing to illustrate the influence of this phase on pattern identification with the use of intelligent systems.

The results presented in Table 3 indicate that after preprocessing the least error in the testing set has been generated with the use of the neural network trained according to the gradient descent momentum with adaptive learning rate algorithm.

The ANFIS obtained better results for the learning set but a little worse results for the testing set than the neural network (GDX). In turn, the ANN trained according to the LM algorithm generated worse results than the ANFIS and the neural network (GDX). This can result from the overtraining of the neural network in the learning phase and the lack of its ability to generalization. The results presented in Table 3 indicate that the intelligent systems are able to generate better results after data preprocessing. This demonstrates the importance of the proper choice of a learning algorithm for ANN and ANFIS, preprocessing the data, and the need of result comparison for different intelligent systems that have ambiguous learning procedures. It is noteworthy that RMSE generated with the use of intelligent systems are smaller than RMSE for the average. The comparison of different forecasting models is especially recommended in the case of significant variance of an output variable.

5.3 Determination of the optimal product portfolio

The relationships between input and output data are stored in the structure of ANN and ANFIS. The fuzzy neural system identified 10 rules that have been used to compute the estimation of net profit for four products {P1, P2, P3, P4}. The values of input variables presented in Table 2 were led to the trained ANFIS structure in order to calculate the forecasts of net profit for the considered products.

Figures 5-8 illustrate the membership functions for the rules that are used for estimating of output variable. Net profit for products P1, P2, P3, and P4 equals 165, 96.8, 192, and 240 monetary units, respectively.

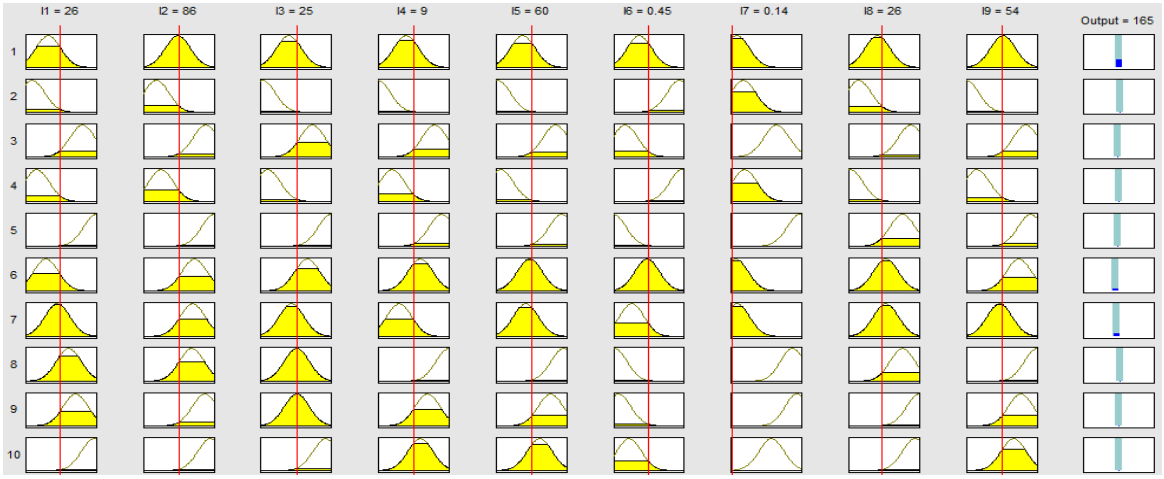

Figure 5. Estimating output variable for product P1
(*source: own elaboration*)

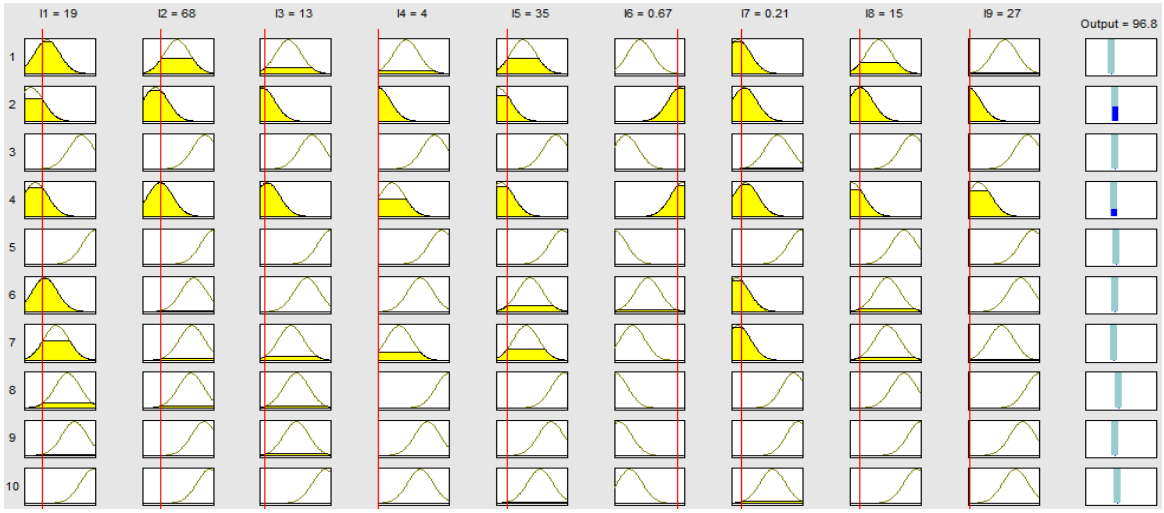

Figure 6. Estimating output variable for product P2
(*source: own elaboration*)

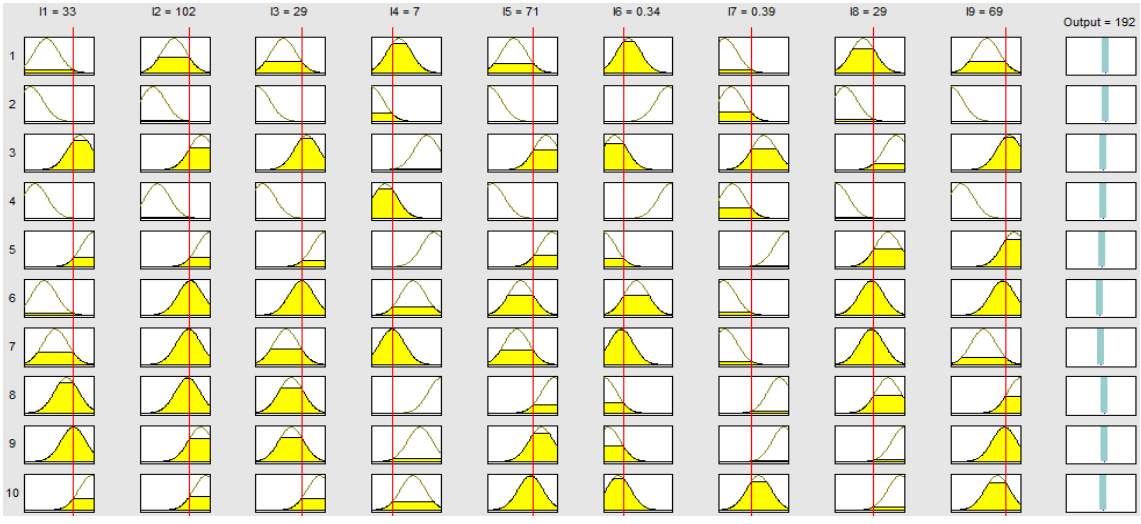

Figure 7. Estimating output variable for product P3
(*source: own elaboration*)

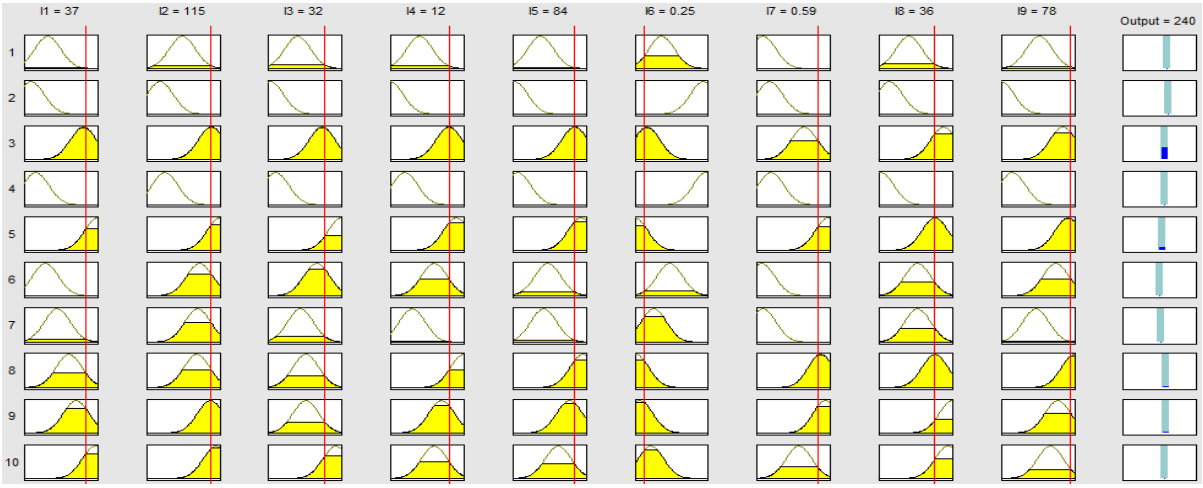

Figure 8. Estimating output variable for product P4
(*source: own elaboration*)

The assumed constraints (21 R&D employees for variable I4 and 148 monetary units for variable I9) limit the number of products to a maximum of 3 out of 4. As the criterion of project selection, the planned net profit from new product has been chosen.

From this point of view, the optimal product portfolio includes product P3 and P4. The presented analysis can be further extended towards the sensitivity analysis, what-if analysis or to obtain an answer to the question what values should have the input variables to reach the desired value of net profit from new product. This question can be considered in the context of the reverse approach [41, 42]. In order to obtain an optimal set of admissible variants, integer programming can be used. In the case of extensive search space, the processing time of calculations can be significantly reduced with the use of constraints programming techniques [34–40].

6 Conclusions

The continuous development and launching of new products is an important determinant of sustained company performance. However, because of its inherent features, new product development is a relatively risky activity. Failed product development projects can decrease market share, profitability, and finally, lead to bankruptcy of a company.

The rapid-evolving technology, the fast-changing markets and the more demanding customers, require developing high quality new products more efficiently and effectively. To ensure these requirements, the identification of the key success factors of product is needed. As an ERP system stores the data connected with the various areas of business, including customers' demand and NPD projects, its database can be used to seek the relationships between these areas and the success of a product.

This paper presents the possibility of the use of an enterprise system database for the identification of relationships between the success of a product and the factors in the field of marketing, customer complaints, production, and project management. The relationships in an ERP database are sought with the use of artificial neural networks and fuzzy neural system that has been compared with the results from linear model. The identified relationships are applied for evaluating the success rate for the products that are considered for the development process and selecting the most promising set of products. Moreover, the influence of data preprocessing on pattern identification has been verified in this study.

The proposed approach has several advantages such as the low effort of data retrieval (the data are accessible in an EPR system that is used by more and more enterprises) and creating new ideas for developing products on the basis of customers' complaints, requirements, and comments that are registered through customer relationship management system.

Moreover, the recognized patterns can be the basis of a decision support system that helps the managers in selecting the most promising product portfolio and reducing the risk of unsuccessful product development.

The proposed approach gives new insights into the literature of pattern identification with the use of an enterprise system database that aims to improve development of new products, and finally, the success rate of products. On the other hand, the application of the proposed approach encounters some difficulties, for instance, collecting enough amounts of data from the past similar NPD projects and ambiguous rules for creating the artificial neural network structure and fuzzy neural system.

Nevertheless, the presented approach seems to have the promising properties for acquiring information from an ERP system and improvement of the decision-making process in the context of selecting new product portfolio.

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0008

THE SOFTWARE COST ESTIMATION METHOD BASED ON FUZZY ONTOLOGY

Przemysław PLECKA*, Krzysztof BZDYRA**

Faculty of Electronics and Information Technologies, Koszalin University of Technology, Poland
*e-mail: przemek.plecka@gmail.com
**e-mail: krzysztof.bzdyra@tu.koszalin.pl

Abstract: In the course of sales process of Enterprise Resource Planning (ERP) Systems, it turns out that the standard system must be extended or changed (modified) according to specific customer's requirements. Therefore, suppliers face the problem of determining the cost of additional works. Most methods of cost estimation bring satisfactory results only at the stage of pre-implementation analysis. However, suppliers need to know the estimated cost as early as at the stage of trade talks. During contract negotiations, they expect not only the information about the costs of works, but also about the risk of exceeding these costs or about the margin of safety. One method that gives more accurate results at the stage of trade talks is the method based on the ontology of implementation costs. This paper proposes modification of the method involving the use of fuzzy attributes, classes, instances and relations in the ontology. The result provides not only the information about the value of work, but also about the minimum and maximum expected cost, and the most likely range of costs. This solution allows suppliers to effectively negotiate the contract and increase the chances of successful completion of the project.

Keywords: ERP, software cost estimation, metrics, fuzzy ontology, implementation, specification of requirements.

1 Introduction

First Enterprise Resource Planning (ERP)-class information systems were available only for very large companies. What appeared to be a barrier in their dissemination was the high cost of implementation and maintenance, due to the fact that software providers created tailor-made solutions for specific customers. Gaining experience from working with many clients, producers identified a set of functionalities that were frequently ordered and created a standard version of their products. The costs of implementation and maintenance were reduced so much that even medium-sized companies could afford such systems [1]. However, standardization causes a situation in which there are groups of business processes that are not supported by a given information system (IS). Hence, there is a need to adapt the system to the customer's company. The cost of such adaptation (modification) increases the value of the contract (implementation). A study by Standish Group [2] shows that in 2012, only 39% of information technology (IT) projects ended successfully. In the rest, the budget or the implementation deadline has to be extended or not all of customer's requirements will be met. The cause of these failures is incorrect cost estimates prior to the onset of the project. Suppliers expect a more complete knowledge on the costs during contract negotiations. Information about the estimated value of the work is insufficient. On this basis, the supplier is not able to assess whether the value of the contract may be reduced by, for example, 5 or 25% under pressure from the client, or a higher value of costs should be negotiated due to high risk of underestimation.

The methods that help to estimate software production costs are known and described in the literature, for example, by McConell [3]. Due to changes in IT and the conditions in IS market, the popularity of these methods is constantly changing. The use of algorithmic methods (*Function Point Analysis, COCOMO*) in the initial stages of projects is difficult. At this stage, the project documentation containing data necessary for estimating algorithms is still non-existent. Although examples of the use of these methods in early stages of the projects can be found in the literature [4, 5], suppliers' experience shows that non-algorithmic methods are applied more frequently (*Expert Evaluation, Estimation by Analogy*) as faster, less-expensive and easier-to-implement solutions. Each of these methods provides only an estimated value of the cost. Additional information, which providers demand, can be obtained using the fuzzy versions of some methods. In the literature, one can find works on fuzzy *COCOMO* method, cf. Fei [6] and Attarzadeh [7] or fuzzy *Function Point Analysis*, c.f.: Xu [8] and Lima [9]. The disadvantage of the fuzzy version, as well as the original ones, is their low accuracy in the early stages of implementation.

The authors' study concerns the search for an alternative method of estimating the cost at the stage of trade talks and pre-implementation analysis. The expected results are not worse than those that can be obtained using the existing methods, and additional information about the possibility of exceeding the cost (underestimation) or the possibility of a cheaper implementation (revaluation) is provided.

Section 1 describes previous research that led to the development of the method based on the ontology of implementation costs and verification of its usefulness which guided towards further exploration on the use of fuzzy attributes, classes, instances, and relationships. The section 2 defines the problem of fuzzing the component attributes of ontology implementation costs and reduces it to a specific class of ERP systems. Section 3 is a quick overview of knowledge about the use of fuzzy ontologies. While section 4 presents an improved method of estimating the costs by focusing on aspects related to the fact of fuzzy attributes. Next, an example of the application of the method, conclusions and suggestions for further research directions are presented.

2 Previous studies

In the course of the study, the efficiency of the already-known methods of estimating the cost of implementation based on previous projects was verified [10]. Significant errors were noted resulting from incorrect selection of methods to the level of data quality (requirements specification) obtained from the client. In the next step [11], an algorithm of selection method, according to the type and quality of information obtained from the client, was proposed. It guaranteed achieving higher accuracy of estimates than it was in the cases studied. However, this solution preferred algorithmic methods (*Function Point Analysis, COSMIC Full Function Point, COCOMO*), which require expertise from suppliers (and are more expensive) and can be used only from the pre-implementation analysis stage. For this reason, a method that can be used at the stage of trade talks was searched for. The use of business process model was proposed as the basis of recording knowledge on the IS and the customer's requirements [12]. The use of the BPMN standard (Business Process Model and Notation) [13] for this purpose allows for earlier dimensioning; it is easy to use and requires no technical knowledge. An additional advantage is the possibility to automate estimations of recording the model processes with the metrics done in Business Process Modelling Language (BPML). The disadvantage of this solution is a limited scope of the representation of data structures (entities). Therefore, another method of dimensioning was proposed—dimensioning based on the metrics included in the ontology of implementation costs (*SICO* - Software Implementation Cost Ontology) [14]. Ontological cost model allows for the representation of both data structures and processes. The low quality of the information obtained from the client in the initial stages of implementation hardly affects the accuracy of the estimation. The supplier prepares IS ontology and completes it gradually with the experience gained from successive implementations. Each occurrence and relationship in the ontology is assigned metrics relating to the costs, for example: *cost of training, cost of parameterization, cost of adding*, etc. Such an ontology is the reference ontology in relation to the ontologies created on its basis. During trade talks and pre-implementation analysis, the supplier modifies the reference ontology based on customer's requirements relating to the IS. In the next step, the difference between ontology containing additional information about customer's requirements and the reference ontology is determined. The result is the collection of unrelated objects, such as classes, relationships and instances. Then the record of differences is converted into a serial format (serialization) and grammatical structure is analyzed (parsing). These processes lead to the selection and aggregation of the values of the attributes relevant to the costs of implementation. In other words, it is assumed that in the context of trade talks, it is sufficient to specify and implement changes resulting from customer's requirements into a well-known ontology to be able to determine the cost of a particular implementation on this basis. The steps of estimating costs with the *SICO* method are shown in Fig. 1.

At the stage of negotiation of the contract, the supplier would expect more complete information about the outcome of the estimation. If, for example, by estimating the costs, the supplier receives a value of 50,000 PLN, the value is increased by the risk margin, for example, 20%, determined on the basis of their experience from previous implementations, and negotiates with the client the value of the contract, e.g. 60,000 PLN.

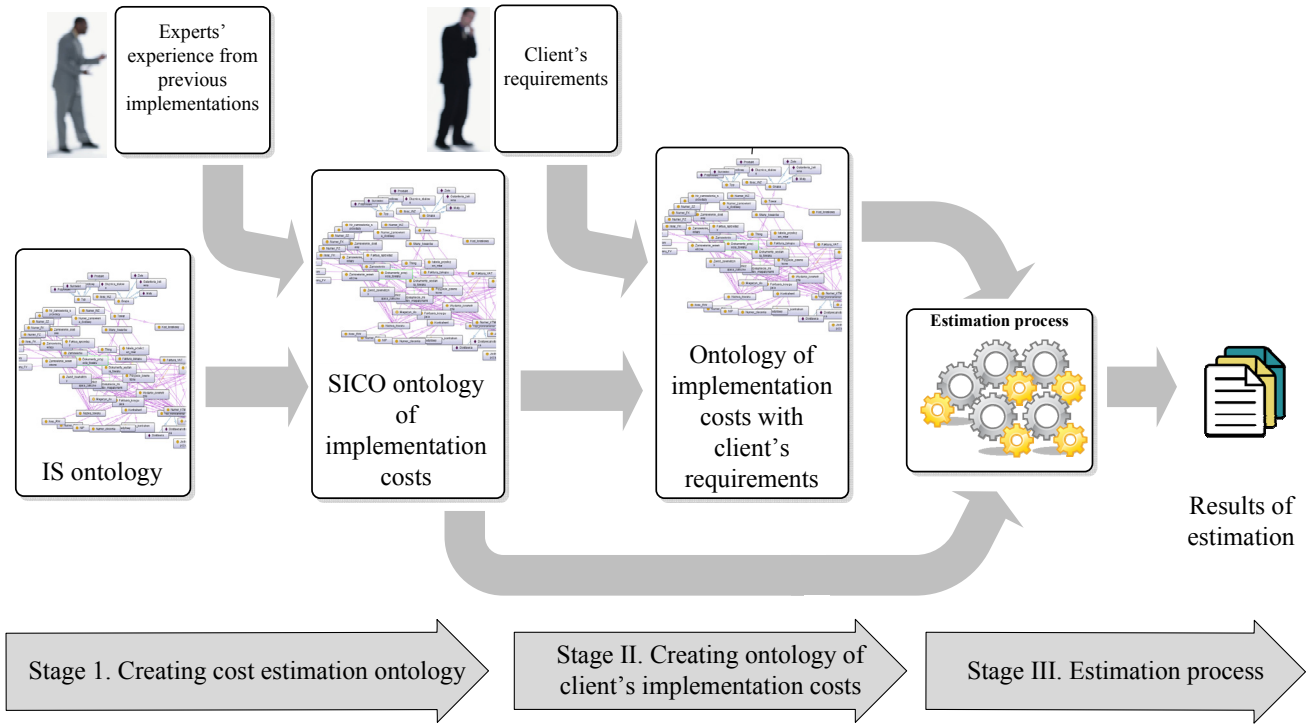

Figure 1. The model for estimating the cost of implementation by SICO method

If the negotiated amount is too small, the supplier loses; if it is too high, he will not be competitive with other suppliers and will lose the contract. Information on the most optimistic (minimum), the most likely and the most pessimistic (maximum) value of costs will allow the supplier negotiate a better contract. The proposed solution is the modified *SICO method using fuzzy* of attribute values in the ontology (*fuzzy SICO*). As a result, the supplier receives three or four values of the costs, for example:

- minimum value: 40,000 PLN,
- most-likely value: 50,000 PLN,
- maximum value: 60,000 PLN.

In this case, accepting the small risk of exceeding costs, the supplier negotiates a contract with a value of 55,000 PLN. He is more competitive then than other suppliers negotiating with the customer. And if in other case, he receives the result of the estimation according to *fuzzy SICO* method, which is different from the previous result by only the maximum value - 75,000 PLN, the supplier still negotiates the amount of 55,000 PLN but accepts the high risk of cost exceeding. In such a case, the value of contract is not lower than 60,000 PLN.

Such deliberate negotiations with the supplier are possible when they are based on fuzzy estimation results.

3 Problem definition

It is assumed that the supplier has an ERP-class IS (Information System) with a specific set of functionalities and experience with the cost of implementation of that system. Supplier's knowledge is stored in the ontology, where implementation costs are represented by fuzzy attribute values of concepts, instances and relationships. The requirements of the medium-sized company concerning the expected functionality of the implemented IS are known. On the basis of these requirements, the supplier changes the components of the ontology of implementation costs. The method of estimating the costs of implementation based on *SICO* ontology is also known. The question is whether the use of fuzzy attributes in the ontology of implementation costs gives estimation results not worse than using "sharp" attribute values. During the evaluation, the results of proposed method are compared with the results obtained using the method of "acute" - *SICO* and other well-known methods. The problem is limited to a specific class of medium-sized companies and their respective ERP systems.

4 Knowledge on ontologies in IT and the use of fuzzy ontology

A few examples of the idea of using fuzzy attributes of the components of the ontology and practical examples of their use can be found in the literature. For example, D. Parry proposed to use fuzzy ontologies for searching through medical records [15]. On the other hand, C. Lee [16] presented a review of the mechanisms of fuzzy ontologies. R. Lau presented the use of fuzzy ontology in e-learning, particularly in assessing the progress of learners [17]. A method for automatic extraction of attributes of concepts, leading to the automatic creation of ontologies was proposed by G. Cui [18]. Examples of the use of fuzzy ontology in decision-making were described by C. Carson [19]. In contrast, P. Alexopoulos proposed a method to convert an "acute" ontology in a fuzzy one [20]. Examples of the use of ontologies in the area of IT can be found in the work of C. Orłowski and A. Czarnecki for evaluating software [21] and the use of ontologies for modeling requirements [22].

5 An improved method for estimating the cost of implementation - fuzzy SICO

In the most popular and widely used method for estimating the costs by an expert or a group of experts [3], the problem is disordered knowledge of these experts. In the process of estimating, the experts "recall" from memory their own experience and "fit" it into current requirements. In this situation, it happens frequently that a considerable experience is omitted or used in the wrong context.

To prevent this, expert knowledge about the costs of implementation is attributed to relevant concepts (classes), instances and relations in the ontology [14]. For example, on the basis of his experience, the expert estimated that the addition of service document "consignment note" into the IS generates the cost *a* and the user training in this area generates the cost *b*. These amounts are the values of the attributes of the concept of "consignment note": the cost of the addition and the cost of training. This procedure is known from SICO methods. During the subsequent implementation, experts notice that the cost of adding the document "consignment note" does not always equal *a*. There are implementations when the cost is a minimum amount of a_1, a_2, is the most frequent amount, but there are cases with the maximum amount of a_3 (case 1). Or there are cases of another IS, when adding the document "consignment note" generates a minimum amount of a_1, the most frequent is the amount between a_2 and a_3, but there are cases that the maximum amount of a_4 (case 2) is generated. Such experiences of experts suggest a way of representing the cost of implementation using a fuzzy model, which allows mirroring phenomena and concepts of ambiguous nature. The reason for fuzzing the attributes of the component ontology is the necessity to re-determine the method of estimating *fuzzy SICO*:

- representation of these attributes,
- method of propagation of attributes onto the superior components,
- methods of summing attributes.

In the theory of fuzzy sets, the degree of membership is expressed as a real number from the interval [0, 1]. A fuzzy set A is defined on a space X then the set:

$$A = \{x, \mu(x)): x \in X\}, \quad (1)$$

where μ: $X \rightarrow [0, 1]$ is the membership function of fuzzy set A. The value $\mu_A(x)$ is the number from the interval [0, 1], and it is called the degree of membership of x element to the set A.

The element x belongs to the set A, if $\mu_A(x)=1$, and it does not, when $\mu_A(x)=0$. Between full membership and lack of membership, there is a smooth transition in the form of partial membership, whose degree is determined by the number of the range [0, 1].

Membership function that describes the collection of a fuzzy set has most frequently a triangular shape (case 1), trapeze (case 2), as shown in Fig. 2. In order to record membership function in the ontology, in particular *fuzzy SICO*, characteristic values can be represented by a vector $M = [a_1, a_2, a_3, a_4]$, where $a_1 \leq a_2 \leq a_3 \leq a_4 \in R$. In particular cases, it may possible that: $a_1 = a_2$ or $a_2 = a_3$, or $a_3 = a_4$,, which has influence only on the shape of membership function.

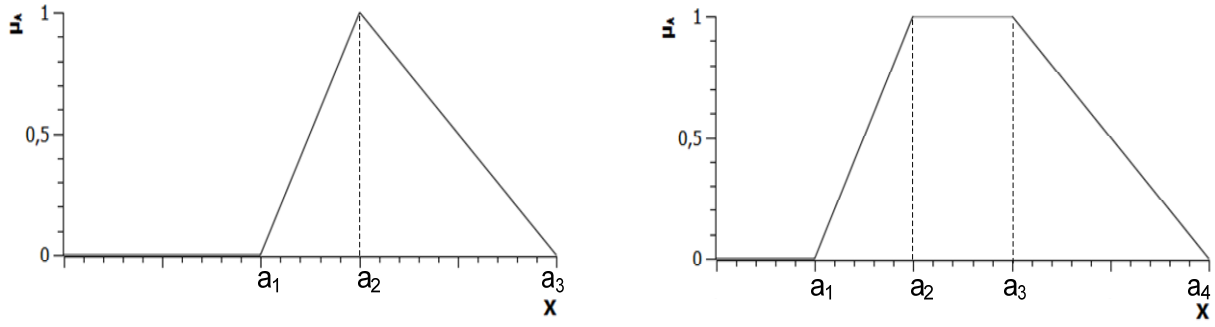

Figure 2. The membership function in the shape of a triangle (case 1) and trapezoid (case 2)

At the first stage, the supplier builds the ontology of IS, attributes expert knowledge on various categories of costs (adding, deleting, parameterization, training) to appropriate relationships and instances. Then the information is transferred towards the superior concepts (propagation). In the method of *fuzzy SICO*, the operation of calculating the value of a superior attribute, which is based on the concept of the values of subordinate attributes or instances, will be a summation according to Zadeh [23]:

$$\mu_{A \cup B}(x) = \max\{\mu_A(x), \mu_B(x)\} \quad (2)$$

Examples of two cases of the summation function of the triangle shape are shown in Fig. 3 and 4.

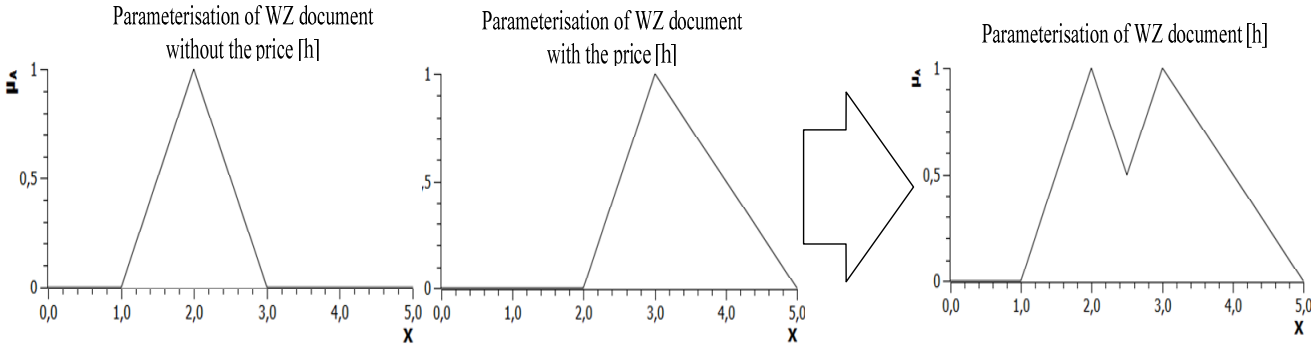

Figure 3. Aggregation of parameterization costs for two warehouse documents

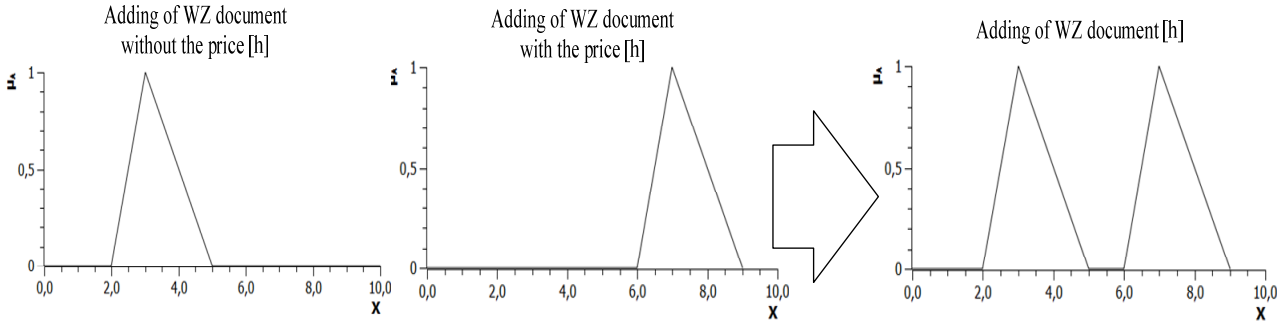

Figure 4. Aggregation of adding costs for two warehouse documents

Concavity of membership function is solely due to incomplete knowledge of experts. In such cases, it is reasonable to highlight their features, as it is shown in Fig. 5 and 6.

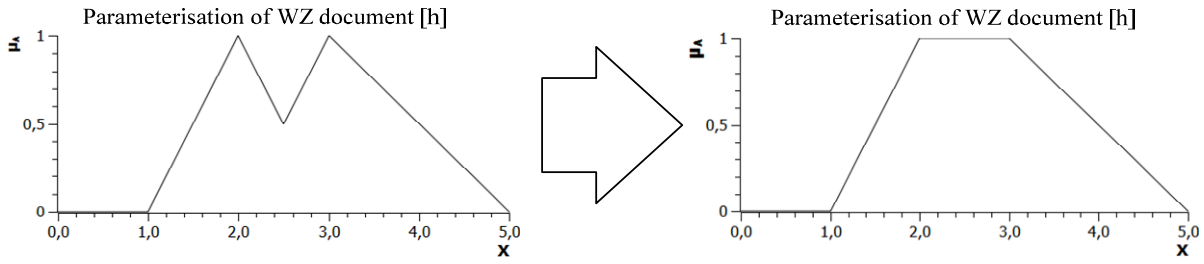

Figure 5. Smoothing the result of the aggregation in case A

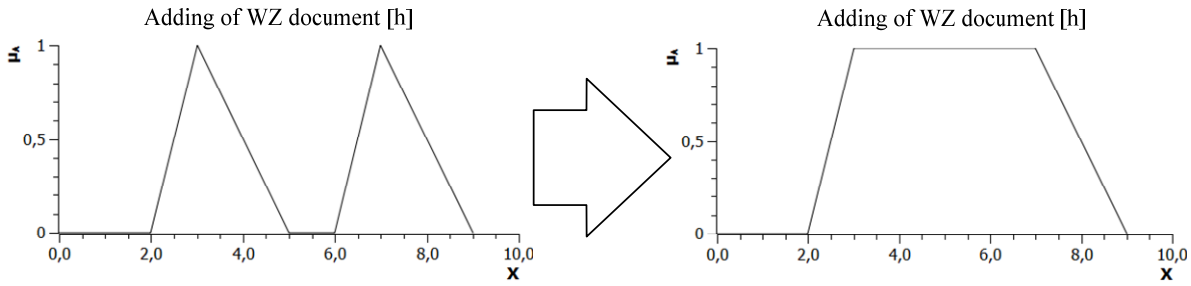

Figure 6. Smoothing the result of the aggregation in case B

At this stage, the supplier already has the ontology containing both a record of IS classes and concepts, as well as the relationship between the classes together and associated attributes that describe the corresponding costs. A part of *fuzzy SICO* ontology of the implementation cost is shown in Fig. 7.

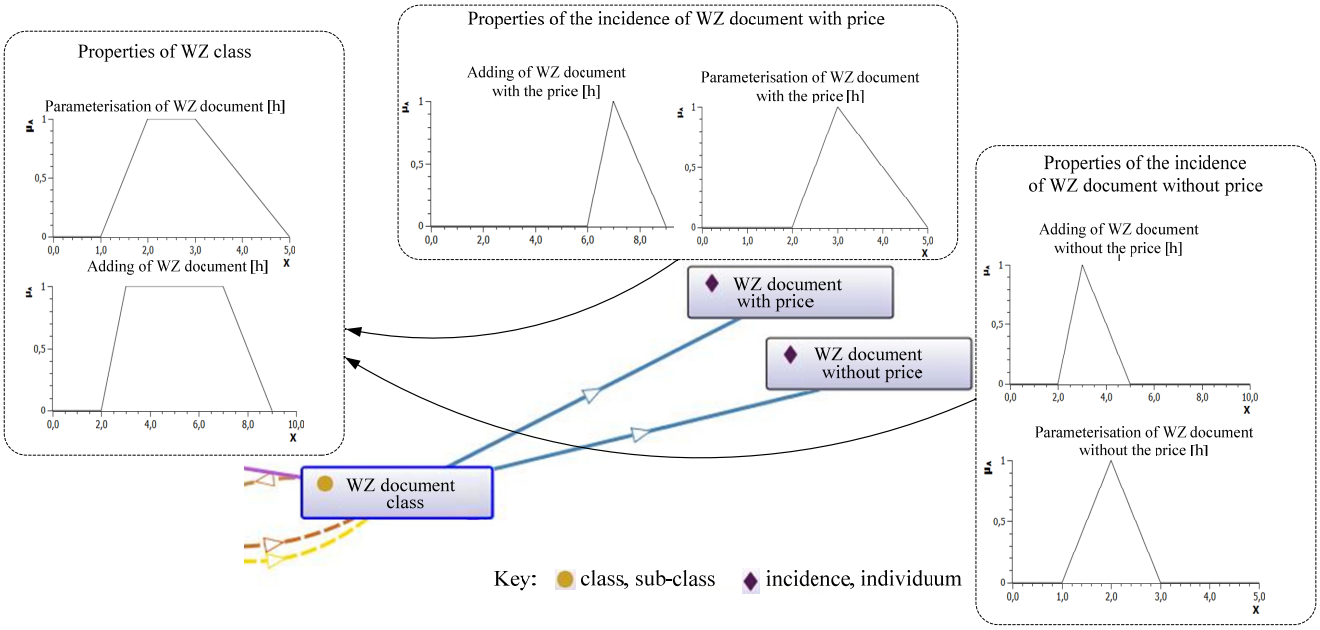

Figure 7. Example of a fragment of the implementation cost ontology with fuzzy attribute values

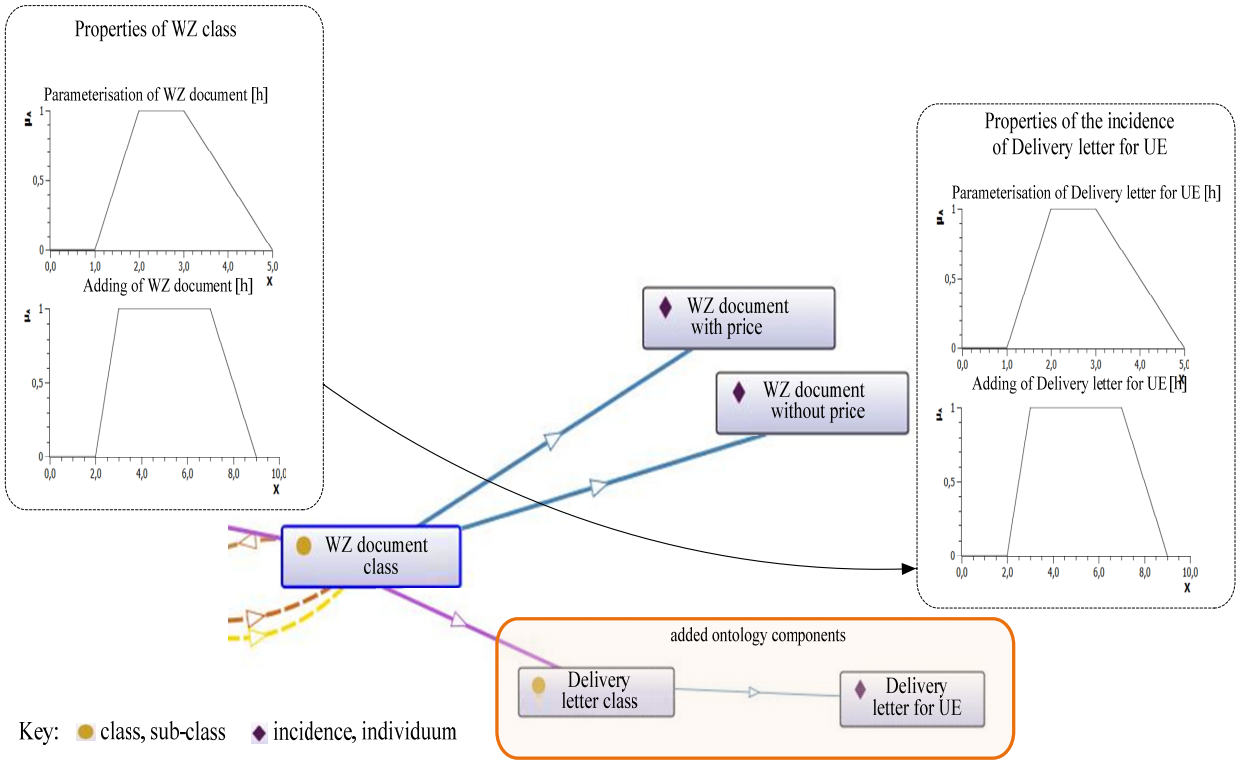

Figure 8. Example of an ontology with the added class and instance

At the next stage, having prepared a reference ontology, the supplier runs an analytical session with the client and makes changes in the ontology based on the customer's requirements.

The following cases of changes in the reference ontology are possible:

i. the addition of classes, instances or relationships,

ii. removal of classes, instances or relationships.

Changes in classes, instances or relationships are realized by removing the object and creating a new one in its place. The added ontology components do not have attributes associated with the costs of implementation. In the process of succession, they are assigned with a set of attributes of the superior object. An example of attributes inheritance by the added class and instance is shown in Fig. 8.

In the case of added relationships, such an operation is not always possible. If the added relationships combine classes A and B, then:

i. if class A and class B do not have any "old" relationships, the expert assigns the costs of attributes using Estimation by analogy [3],

ii. if class A or class B have the "old" relationships, the relationship A-B receives all the attributes that exist in the relationship of class A or B, and its values are calculated as the sum by Zadeh.

The next process in cost estimation is the differentiation of the reference ontology and the ontology changed as a result of specific customer's requirements. The results of differentiation are two lists of objects, such as classes, relationships and instances with attributes assigned to them. In both lists, classes and their attributes are removed as they do not affect the costs.

The first list contains the objects removed from the reference ontology. From this list, the values of the attribute cost of removing are selected and aggregated. The second list contains the objects that were added to the ontology as a result of customer's requirements. From this list, the values of attributes, for example: the cost of addition, the cost of parameterization, and the cost of training are selected and aggregated. Aggregation is done according to the following formula:

$$\mu_{A+B}(x) = \max\{\mu_A(y), \mu_B(z) \mid x=y+z\} \quad (3)$$

An example of aggregation of membership function is presented in Fig. 9.

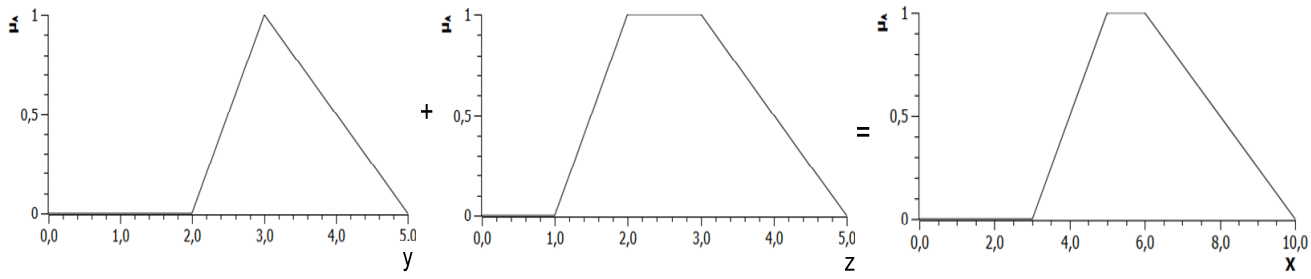

Figure 9. Example of aggregation of two membership functions - *the cost of parameterization*

The values of the attributes of the cost of the addition, the cost of parameterization, the cost of training, and the cost of removing define the supplier's additional costs of implementation arising from specific (non-standard) customer's requirements.

6 Example of application

The verification of the proposed method was carried out on the example of estimating the cost of IS changes in a medium-sized manufacturing company of the shipbuilding industry. After a year of implementation of a standard version of the IS in the production area, the client reports a new requirement associated with product safety certifications introduced into production and specifies that the allocated budget for this change in the amount of 9,000 PLN. During the trade talks, the company reveals, among other things, that the raw material from group A are supplied with safety certificates to be attached to the final product sold to the customer, and a copy should be stored in electronic form in the archive.

At this stage, the only methods of estimating costs that can be used are the Individual Assessment by the Expert or a Group of Experts. The supplier estimates the value of the work by the Individual Expert Assessment at 5600 PLN, which means he can undertake the works. During the implementation analysis, the supplier specifies the requirements of the exact contents of the new document (number and types of fields), and obtains additional information. Having completed the requirements, the cost of IS changes is estimated by the supplier according to the Function Point Analysis and after the adjustment, the value of 32 Function Point (FP) is obtained.

On the basis of previous projects, the supplier determines the value of 1 FP equal to 230 PLN, which gives an estimated value of 7,360 PLN.

Then the supplier performs the valuation using the *SICO* method. The first estimate is made at the stage of trade talks. On the basis of the disclosed customer's requirements, the reference ontology increases by two classes associated with classes *Purchase documents* and *Sales documents*, two instances (Certificate_doc and Certificate_img) and 12 relationships between the added and the existing classes.

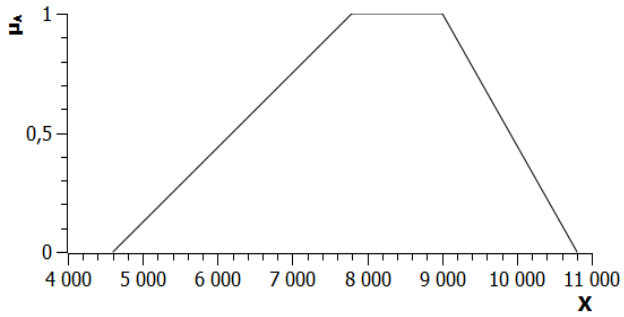

Figure 10. The results of estimations at the stage of trade talks

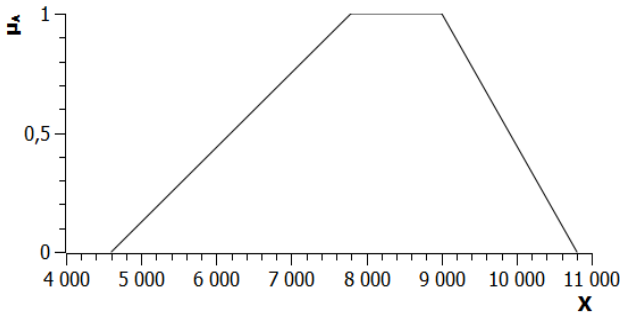

Figure 11. The results of estimations at the stage of pre-implementation analysis

Table 1. Comparison of cost estimation errors at initial stages of implementation

Cost estimation method	The stage of trade talks	The stage of pre-implementation analysis
Estimation of a group of experts	35%	-
Function Point Analysis	-	14%
SICO method	26%	8%
Fuzzy SICO method	9%	5%

Classes and instances inherit the metric *cost_of_adding* from the superior objects, while the added relationships value of this metric is determined by the expert. After determining the difference between the modified and reference ontology, the total value assigned to the metric *cost_of_adding* is 6400 PLN. After pre-implementation analysis, another 9 relationships are added, which increases the estimate up to 7900 PLN.

At the same time, the supplier carries out the valuation using the method of *fuzzy SICO*. Changes in classes, instances and relationships are the same as in the *SICO* method. After determining the difference between the modified and reference ontologies, membership function is the sum of the metrics cost of adding M1 = (4,600 PLN, 6,800 PLN, 7,800 PLN, 9,800 PLN), as shown in Fig. 10. This means that the most likely cost of implementation is between 6,800 and 7,800 PLN. In extremely disadvantageous situation, it does not exceed 9,800 PLN, but is not lower than 4,600 PLN.

Among the many strategies of de-fuzzing [24] only the strategy of the highest maximum (LOM - Last of Maximum) is useful for the supplier in the process of contract negotiations. On this basis, the supplier determines the value of the contract at 7,800 PLN. After pre-implementation analysis, the supplier adds another 9 relationships to the ontology and the estimate increases to M2 = (4,600 PLN, 7,800 PLN, 9,000 PLN, 10,800 PLN), as shown in Fig. 11. This means that the most likely cost of implementation is between 7,800 and 9,000 PLN. In extremely disadvantageous situation, it does not exceed 10,800 PLN and it is not lower than 4,600 PLN. On the basis of LOM, the final cost of the implementation is 9,000 PLN. The supplier consciously undertakes the work considering the risk of exceeding the cost up to 10,800 PLN.

The primary criterion of evaluation for each method of estimating is the error of the results. For IT projects, this error is known only after the implementation of the entire IS, when the estimates and the actual cost of the work are compared. After the implementation of this project, the analysis of cost reports shows that the value of the work delivered to the customer is 8,600 PLN. A comparison of the estimation errors of each method is shown in Table 1.

On the basis of the analyzed case, it can be noted that cost estimation, according to the method based on fuzzy attribute of *fuzzy SICO* ontology gives no worse results than the other known methods. In particular, it should be noted that at the stage of trade talks, the result is much better (more accurate) than the estimation by a group of experts and the *SICO* method.

7 Conclusions

The method of estimating the implementation costs that uses fuzzy attributes in fuzzy *SICO* ontology gives suppliers greater benefits than previously known methods. Its advantages should be seen not only in no worse results, but above all in the fact that supplier's knowledge is extended by the range of the expected costs. This allows suppliers to take conscious risk of cost exceeding, if during the negotiations they are forced to reduce the value of the contract because of competitiveness.

In future studies, verification of *fuzzy SICO* methods will be extended with further estimation cases, in order to confirm the accuracy that is not worse than other known methods. In addition, the research will be complemented by de-fuzzing strategies. The known strategies are not fully satisfactory for the suppliers in the process of determining the value of IS implementation.

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0009

TOWARDS AN ANALYSIS METHODOLOGY FOR IDENTIFYING ROOT CAUSES OF POOR DELIVERY PERFORMANCE

Peter NIELSEN[1]*, Ngoc Anh Dung DO*, Thomas ERIKSEN**, Izabela NIELSEN*

*Aalborg University, Department of Mechanical and Manufacturing Engineering, Denmark
e-mail: peter@m-tech.aau.dk
**CS BtB Operations Center, Telenor ASA Group, Denmark

***Abstract*:** This paper presents an analysis methodology for establishing the demand stability of the planning environment faced by a company and the impact on the stability from changes to sales order. The methodology focuses on three critical planning parameters derived from customer orders: product mix, volume, and order sizes. Furthermore, the methodology links the delivery performance of a company to the changes made to sales orders. Based on a test case application of the methodology, it is concluded that by accepting changes, the demand faced by the case company has become more unstable on product mix, volume, and the number of order lines per period, while some added stability has been achieved with regards to the order size distributions. Ultimately, by applying the methodology to the case company, it is found that by changing the sales orders, the company does not improve the delivery performance.

Key words: Business Intelligence, diagnostics, Decision Support Systems, Performance Improvement Systems.

1 Introduction

The main challenge in today's businesses is not getting enough information to make qualified decisions, but rather structuring the information already available in a manner that facilitates pro- and reactive actions to improve the performance of the business. Nowadays, manufacturers compete not only on the prices of supplied products but also on the services supported to the customers. On-time delivery is one of the most important services that a manufacturer has to provide and thus on-time delivery becomes a critical performance measure. The importance of this increases if the manufacturer is placed early in a supply chain. The lateness of the delivery of an upstream supplier chain affects the plans of all downstream companies and the total cost of supply chain increases.

In manufacturing planning and control literature, much attention is given to the terms volume and product mix [4, 25]. These are often seen as the critical parameters (together with the competitive priorities; quality, flexibility, reliability, and speed) when designing and evaluating supply chain or manufacturing planning and control systems. Furthermore, it is known that many companies focus in some manner on On-Time-in-Full (OTIF) delivery of customer orders as their main performance goal [16]. Despite extensive literature on this topic, very little attention has been given to the connection between delivery performance and the stability of the planning environment in the form of the demand faced by the manufacturer. In order to establish this connection, this research investigates the impact of changes to sales order lines on the stability of the planning environment and links these changes to the delivery performance of a company.

It is known that the delivery performance is much affected by the frequency and type of changes to the production schedule, especially so in Make-To-Order (MTO) manufacturers, where each customer order is directly linked to the production schedule and it is difficult to get high delivery reliability [4]. As product mix and volume stability are critical in determining stability of the schedule, they should by definition also significantly influence the delivery performance. When these two factors are unstable, the manufacturer has to reschedule production activities or reduce the process lead time in order to meet the delivery requirement.

However, rescheduling the production activities and reducing the process lead time are costly or even infeasible. Another often overlooked element derived from volume and mix is the order size distributions. The distribution of order sizes, both in the form of average order size, number of orders, and variation in order size are critical as they directly impact the need for setup changes and thereby also the utilization and throughput of a manufacturing system. Furthermore, unstable order sizes will tend to indicate that the total demand for individual products is unstable.

[1] Corresponding author

The motivation for this research is the long-term development of a complete diagnostic methodology that considers and enables diagnosis of the manufacturing planning and control system, by examining the inputs and changes to the system. In this context, the paper presents a step towards developing a comprehensive analysis methodology for identifying root causes for poor delivery performance. The paper is an extended version of a paper presented at the Industrial Engineering and Systems Management (IESM) 2011 in Metz [20] and focuses on three critical planning parameters; product mix, volume, and order sizes and presents a number of methods to analyze these areas. Specifically, the analysis methodology focuses on establishing the stability of the planning environment faced by the company in the form of demand and the impact of changes to sales order lines on the stability. A stable planning environment is in this context considered to have the following attributes:

- the product mix is stable, that is, the product mix does not vary from planning period to period,
- the demand is stable, that is, the demand is constant in volume from planning period to period,
- the order sizes are constant or follow a symmetric distribution.

An order is a set of requirements on the volume of different products and the delivery deadline of each type of product. Basically, the delivery deadline of each product type can vary. A requirement on volume and due date of each product type in an order is defined as an order line. This paper likewise introduces three different OTIF delivery performance measures that give a ratio of order lines, volume, and revenue, respectively, satisfactorily delivered OTIF.

These measures are chosen in a manner ensuring that they can be applied in various industries and companies. The main aim of the presented research is to establish both the stability of the demand faced by a company and to establish whether or not the company is stabilizing or destabilizing the planning environment by accepting or instigating changes to customer orders, thereby potentially affecting the delivery performance. Changes to customer orders are especially significant when diagnosing the actual performance of a manufacturing system and the supporting business processes.

The remainder of the paper is structured as follows. First, a literature review discussing the main parameters product mix, volume, and order sizes is presented. Second, an analysis methodology focusing on these areas is outlined. Following this is a paragraph on a data gathering framework and a case application of the methodology. Finally, conclusions and future research are presented.

2 Literature review

The design choices presented here are primarily related to the market being addressed and to some extent, the internal capabilities of a company. Delivery performance is investigated in some papers [4, 14, 23]. Brown *et al.* (2001) measure the effects of inventory inaccuracy in Material Requirements Planning (MRP) inventory and delivery performance for lot-for-lot and fixed-order-quantity policies by using simulation [4]. Lane and Szwejczewski (2000) investigated the relative importance of planning and control systems to achieve good delivery performance. They found that a responsive planning and control system is significantly more important than worker flexibility and quick changeover in achieving good delivery performance for MTO manufacturers [14]. Stefansson *et al.* (2009) proposed a computationally efficient procedure for production plans and schedules under uncertain and varying demand conditions for reducing the risk of delayed delivery in MTO production [23].

Many of the main design criteria deal with the relative volatility of the demand faced by the company, that is, the volatility of the volume and of the product mix. Normal design practices state that for volatile product mixes, the customer order decoupling point is moved backward [4, 13, 21]. In general, a number of parameters can be identified that are critical when establishing which manufacturing planning and control scheme to follow in a given situation. These can be categorized into internal and external factors.

The internal factors include, for example, the resources available to the company, the layout of production, etc. The external can be portioned into down-stream and up-stream influences. This paper focuses on the down-stream influences on the manufacturing planning and control system. The down-stream influences on the manufacturing planning and control system are driven by the market faced by the company and the position of the company on this market. These market conditions in practice manifest for the planning environment in the form of: volume, product mix, and order size volatility.

Certain criteria of stability for product mix and volume stability have been proposed and tested in literature, see for example [17].

2.1 Product mix stability

Product mix flexibility is often described in the terms of how cheaply a given product mix can be produced [11]. Thus the flexibility term is often related to a number of internal attributes of the manufacturing systems and the suggested measures are as such related to the internal cost structure of the company [7].

However, these measures as such state nothing of the inherent stability of a given product mix, but only the response of the manufacturing system to a given mix. Some limited work has been presented on a number of measures for establishing the stability of a product mix [17]. These are presented and briefly discussed below. From Nicholas [15], it is also known that the product mix has importance for the ability to balance production lines and that a more volatile/unstable product mix results in higher buffering costs. Thus, a stable product mix from period to period is desirable.

Some issues of unstable product mix (e.g. raw material purchasing) can be addressed through forecasting the product mix per period accurately. However, the manufacturing system as such is still designed with a specific product mix in mind, and deviating too far from this will cause an increase in operating costs or poor delivery performance.

2.2 Volume stability

Volume stability, both in the volatility of volume and the number of orders per period, has a significant impact on the performance of manufacturing systems. In theory, two manufacturing strategies exist to deal with volume instability, chase or level [26].

The chase strategy involves buffering (in any number of ways) to enable matching the variance in volume from period to period. In practice, this means having excess inventory and capacity available to absorb deviations from the expected mean volume per period.

The leveling strategy assumes that the volume can be leveled between planning periods, through moving delivery dates and quantities. In practice, this can be undesirable due to customer expectations and the market conditions faced by the company. Studies by, for example, Ceryan and Koren (2009) address the impact of demand volatility and the impact of this on the design of a manufacturing system [6]. The conclusion is straightforward, the more volatile the demand, the better the higher cost and flexible manufacturing system performs. In changeover heavy manufacturing environments, the volatility of the number of order lines per period can substitute the volatility of volume.

2.3 Order size stability

Order sizes are a critical parameter when designing manufacturing environments [15]. The number of orders and the distribution of the order sizes are critical for a number of issues.

First, to facilitate the aggregation and disaggregation of plans a number of assumptions are made [3] with regards to the orders handled by the system. The assumption is a one-to-one relationship in aggregation and disaggregation [12]. As a result, order sizes and the number of orders per period are assumed to be constant, to facilitate calculation of time needs for changeovers and the number of changeovers needed per planning period and thus the expected throughput rate of the system. If this is not the case, the disaggregation of plans may result in suboptimal or even infeasible disaggregate plans.

Second, to achieve a proper line balancing, the order sizes should either vary in a predictable independent identically distributed (i.i.d.) manner or be stationary over time [15]. In general, the consensus in literature is either to assume a constant number of orders and order size within a planning period or to assume that the order sizes follow a known symmetrical distribution and are i.i.d.

2.4 Current state of performance measurement reporting – Business Intelligence/Diagnostics

Through the last decade, Business Intelligence systems have emerged as an important tool in industry to track performance and to report this to managers. Basically, Business Intelligence systems assist in creating a dynamic and easy-to-understand overview on the vast amount of data available from the IT-systems within the company.

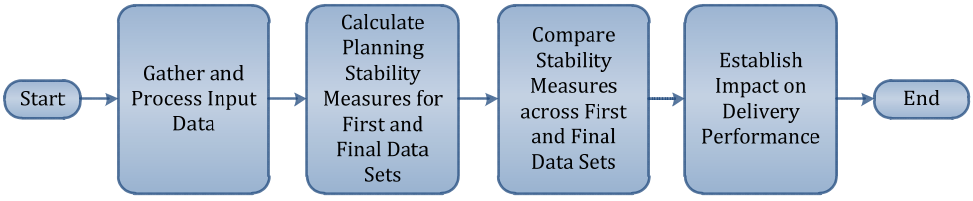

Figure 1. Flow chart of analysis methodology

Business Intelligence systems are often used in performance management as a tool for automatically calculating and communicating performance measures to selected users of the systems, typically management.

This allows defined performance measures to be used in performance management activities, in terms of a set of performance indicators, which can be narrowed down to a set of key performance indicators. Key performance indicators thus assist in identifying areas of the business where performance is lower or greater than expected, that is, differing from a target value [7].

Although being an important enabler of monitoring performance effectively, today's Business Intelligence tools are, however, limited to only identifying areas with performance issues, not the underlying causes. The job of explaining "why" and "how", that is, diagnosing performance issues occur lies within the scope of manual interpretation and evaluation of measurement results from the Business Intelligence system, and can be expensive, tedious, and subject to errors [22].

Automated interpretation and evaluation concepts to move from Business Intelligence towards a proactive diagnostic approach have been successfully applied to specific domains within companies, such as finance [10] and productivity [22]. These attempts reveal that it is possible to automate the diagnosing activities. However, current literature does not give any indication for a generic framework for diagnosing delivery performance issues, or operational performance issues related to manufacturing companies.

The aim of this paper is to some extent remedy this inadequacy, by exploring some of the immediate potential causes to poor delivery performance, that is, unstable planning environment, including changes to accepted sales orders, and combine this information with the performance observations. The value added to traditional Business Intelligence added from this diagnostic approach quantifies the effect of known causes enabling filtering with a significance level. In the following paragraph, an analysis methodology that can be automated and used for diagnostics in a generic manufacturing environment is presented.

3 Analysis methodology

In Figure 1, the 'first data set' means the information of the original orders from the customer. After that, these data can be changed based on the negotiations between the company and its customers. At the end of these negotiations, the data set is fixed, which means that there is no more change.

The fixed data set is called the 'final data set' in this paper. The analysis methodology illustrated in Figure 1 consists of a number of steps.

The first step includes gathering and preprocessing the input data for the methodology. This step includes logging the changes to sales lines, identifying the delivery dates, quantities, and product ID. This allows tracking changes and evaluating the impact on the relevant parameters identified in section 2.

The second step includes sequentially calculating the product mix, volume, and order size stability for respectively the first and final promised delivery dates and quantities for all order lines included in the analysis. This step is conducted with user defined time windows – for example, the time window for comparison of stability can range according to the size of the data set and the requirements of the planning environment.

The third step is the comparison of stability on all criteria between the first promised delivery date and quantity for each sales line and the final (before delivery actually takes place) promised delivery date and quantity for each sales order line.

The last step in the analysis is the establishment of the impact of changes to sales orders on delivery performance.

The results of the analysis will then answer the following:

1) are the changes to the sales orders improving/degrading the stability of the planning environment?

2) are the changes to sales orders resulting in a better/worse delivery performance?

This is done through investigating whether orders with on-modified delivery dates and/or quantities have a lower delivery performance than orders that have been changed.

The proposed analysis methodology investigates the following elements: product mix, volume, and order size stability, OTIF delivery performance, and the impact of changes to delivery performance. The analysis methodology relies on data gathered directly from the database of any Enterprise Resource Planning (ERP) system and enriched by a database containing all transactions and changes to sales orders.

3.1 Measurement of product mix stability

Nielsen *et al.* [17] present a number of measures to establish the stability of a product mix. These measures are shown below.

$$\text{Variation of ratio} = \frac{\sum_{i \in n} \frac{\sigma_{i,t}}{x_{i,t}}}{n} \quad (1)$$

Where $x_{i,t}$ and $\sigma_{i,t}$ are respectively the mean ratio of sales and standard deviation of the ratio of sales for the product i over the whole time period with the time window of length t. n is the total number of products in the whole set. The ratio of sales is defined as the ratio between the sale of product i and the total sale of all products. If a product's sales are completely stable, the $\sigma_{i,t}$ /$x_{i,t}$ ratio is zero. So for the completely stable product mix, this indicator should be zero. Due to the inclusion of a variance term, this indicator will tend to react more to large changes in the ratio of sales for a given product.

$$\text{Relative span of rank} = \frac{\sum_{i \in n} \frac{Max\left(R^*_{i,t}\right) - Min\left(R^*_{i,t}\right)}{n}}{n} \quad (2)$$

Where $R^*_{i,t}$ is a vector of the product i's ranks with the time window length t. Rank is calculated in descending order, so that the product with the highest ratio of sales for a given time window is given rank 1. This criterion establishes the average relative range of ranks a product with a given time window size. This indicator should likewise be zero for a completely stable product mix. This criterion tends to punish product programs where many products are introduced and phased out. Thus this indicator can also be considered interesting when analyzing product lifecycles in relation to changes in product mix.

$$\text{Inclusion} = \frac{\text{Number of occurences of non included products}}{\text{Total number of occurences}} = \sum_i \frac{\sum_j Y_{i,j}}{t} \quad (3)$$

This indicator describes how many times a given product is not in the product mix with a given time window. If product i is not in the product mix in period j, than $Y_{i,j} = 1$; otherwise, $Y_{i,j} = 0$. This indicator should likewise be zero for a completely stable product mix, indicating that all the products are sold in all time windows.

3.2 Measurement of volume stability

To determine the variation in volume, the well-established term coefficient of variance (CV^V) is used [used in e.g. (1, 25)]. This term is simply:

$$CV_j^V = \frac{\sigma_j^V}{\mu_j^V} \quad (4)$$

Where μ_j^V is the sample mean of the volume per period of length j and σ_j^V is the standard deviation of the observed volume per period of length j. A similar term coefficient of variance for the number of Order Lines (CV^{OL}) is introduced. This term is simply:

$$CV_j^{OL} = \frac{\sigma_j^{OL}}{\mu_j^{OL}} \quad (5)$$

Where μ_j^{OL} is the sample mean number of Order Lines per period of length j and σ_j^{OL} is the standard deviation of the observed number of order lines per period of length j. For both CV_j^V and CV_j^{OL} a low value indicates low variation in respectively the volume sold and the number of order lines per period.

3.3 Measurement of order size stability

To measure the order size volatility, a number of standard statistical methods will be used. These include again, coefficient of variance of order size (CV^O), kurtosis and skewness of the distribution of the order sizes in each period and the coefficient of variance for the average order size (CV^{AO}) over all periods.

Likewise, the independence of the order sizes' distributions is checked. In this manner, all the assumptions regarding the distributions and behavior of the order sizes is investigated using autocorrelation (Box and Jenkins, 1970).

Coefficient of variance of order size

$$CV_j^O = \frac{\sigma_j^O}{\mu_j^O} \tag{6}$$

Where μ_j^O is the sample mean of order size in period *j*and σ_j^O is the sample standard deviation of the order size in period *j*.

Coefficient of variance of average order size

$$CV^{AO} = \frac{\sigma^{AO}}{\mu^{AO}} \tag{7}$$

Where μ^{AO} is the sample mean of average order size in a given time window *t* and σ^{AO} is the sample standard deviation of the order size in a given time window *t*.

3.4 Linking delivery performance to changes in the planning environment

After deriving the measures for the planning stability, that is, stability of product mix, volume, and order sizes, the next step is to calculate the actual delivery performance and the resulting impact on performance of accepted order changes. This is done indirectly by calculating the number of changes on sales order lines per product type and various measures of OTIF delivery performance. The aim is to see if products with many changes to delivery data (quantity and date) have a higher delivery performance than products with few changes. This is easily achieved by calculating the Pearson correlation between the number of changes and the delivery performance per product, and subsequently establishing the significance of the correlation.

The comparison measure is thus an indirect measurement of whether orders that have had many changes have a significant higher delivery performance than orders with no/few changes. To ensure proper comparison, the number of changes are measured 'per order line' for the product in question.

Previous research into the area of delivery performance has shown that a suite of multiple OTIF measures is desirable [9]. The three measures used in this methodology are Revenue (R-OTIF), Volume (V-OTIF) and Order Line (OL-OTIF). These are defined as follows:

$$\text{R-OTIF} = \frac{\text{Total revenue delivered on time}}{\text{Total revenue delivered}} = \frac{\sum_i Q_i R_i}{\sum_n Q_n R_n} \tag{8}$$

$$\text{V-OTIF} = \frac{\text{Volume delivered on time}}{\text{Total volume delivered}} = \frac{\sum_i Q_i}{\sum_n Q_n} \tag{9}$$

$$\text{OL-OTIF} = \frac{\text{Number of order lines delivered on time}}{\text{Total number of order lines delivered}} = \frac{\sum_i OL_i}{\sum_n OL_n} \tag{10}$$

where $i \in$ set of order lines delivered ontime

$n \in$ all delivered order lines

Q_i is the volume of an order line *i*

R_i is the revenue per unit of product according to order line *i*

OL_i is the order line *i*

The three delivery performance measures have the advantage that they can be compared across markets, products, companies, industries, etc. since they are unitless. If absolute terms such as lead time or cost of delivery were used, comparisons across industries or even business areas within the same company become difficult. The aim of this research is to work towards a generic methodology, this must by necessity imply the need for generic measures of delivery performance. Like any analysis method, the presented methodology has limitations in application. First, the methodology requires a transaction-rich environment to give precise answers. Terms such as CV^V, CV^{OL}, product mix stability, and order size stability as calculated in this context improve in precision as the number of observations increase. A further application limitation must be recognized.

Table 1. An overview of the input data used for the case application of the analysis methodology
(The analysis uses 10 weeks of data; the values in the table below indicate the total for the whole 10-week period)

Data set	Number of unique products sold in total	Total number of sales lines	Total volume of products promised for sales
Original sales orders	107	686	1861
Final sales orders after changes	113	719	1568

Table 2.The product mix stability criterion for 1- and 2-week aggregations of sales,
for respectively the original and the last promised delivery dates and quantities

	Original sales orders		Final sales orders after changes		Deviation		Relative deviation	
	1 week	2 weeks	1 week	2 weeks	1 week	2 weeks	1 week	2 weeks
Inclusion criterion	0.71	0.57	0.72	0.61	−0.01	−0.04	−1.4%	−7.0%
Relative span of rank criterion	0.84	0.75	0.85	0.73	−0.01	0.02	−1.2%	2.7%
Variation of ratio criterion	2.21	1.64	2.21	1.66	0.00	−0.02	0.0%	−1.2%

The analysis methodology should be applied to sales data for products with similar impact on the manufacturing planning and control system. A natural discrimination would be products from the same product family. However, this is not an unreasonable limitation since indiscriminate application of the methodology without limiting the scope of analysis will also render the interpretation of results difficult if not impossible

4 Case test of methodology

The analysis methodology has been implemented in a medium-sized manufacturing company. The company accepts changes to sales orders both initiated from customer requests and when production constraints occur, to create a more feasible production plan for an OTIF delivery. In the context of this research, the cause of changes to sales orders is not logged since only the impact on the planning environment is considered. Currently, the company has no knowledge of how the number of changes affects their delivery performance or performance in general.

To assist in providing this information, a data logger prototype has been developed and implemented and has been running at the case company for several months. The prototype is based on a generic framework applicable in any ERP-environment [9].

The prototype works by identifying changes made to sales orders on a daily basis by comparing the two latest versions of the same order line. Each subsequent change to a sales order line is then logged. In this way, it is possible to identify how often products are delivered exactly as the customer requested it initially and how often and what changes are made to each sales order line [9].

For the purpose of this case test of the analysis methodology, the main product family in the company is selected for analysis. A total of 10 weeks of full delivery and order promising is available for the test. Only periods for which all changes have been registered and all sales order lines have been delivered are desirable for the analysis. Two levels of aggregation of time periods are chosen for investigation, 1 and 2 weeks.

Table 1 shows the number of orders, the number of unique products (SKUs*1*) sold and the total volume of the orders in respectively the first promised and last promised delivery dates and quantities. As can be seen from Table 1, for better clarity, information aggregates show some changes have occurred to the sales order lines. Six new products have been introduced to the mix, the number of order lines has increased by 5% and the volume has decreased by 16%.

[1] stock-keeping units

Table 3. Volume and number of order lines per period comparison using both 1 and 2 weeks of aggregation

	Original sales orders		Final sales orders after changes		Deviation		Relative deviation	
	1 week	2 weeks	1 week	2 weeks	1 week	2 weeks	1 week	2 weeks
CV^V	0.74	0.45	0.86	0.58	−0.12	−0.13	-16.2%	−28.9%
CV^{OL}	0.37	0.32	0.49	0.41	−0.12	−0.09	-33.0%	−29.5%

Table 4. The kurtosis, skewness, and covariance of order size in 10 weeks

Period	Kurtosis			Skewness			CV^O		
	First data set	Final data set	Difference	First data set	Final data set	Difference	First data set	Final data set	Difference
Week 1	2.33	7.76	233%	1.88	2.75	46%	0.46	0.89	92%
Week 2	30.13	6.97	−77%	5.59	2.58	−54%	4.94	1.26	−74%
Week 3	21.18	9.67	−54%	4.39	3.04	−31%	2.25	1.02	−55%
Week 4	12.08	26.62	120%	3.46	4.87	41%	0.69	1.48	113%
Week 5	60.74	86.88	43%	7.38	8.86	20%	2.99	4.03	35%
Week 6	42.36	15.15	−64%	6.13	3.77	−39%	1.27	0.56	−56%
Week 7	17.80	7.69	−57%	4.08	2.76	−32%	0.98	0.88	−9%
Week 8	6.29	9.70	54%	2.58	2.67	3%	1.17	0.77	−34%
Week 9	39.80	35.10	−12%	6.08	5.69	−6%	1.49	1.28	−14%
Week 10	28.98	10.60	−63%	4.82	3.15	−35%	1.06	1.12	5%

This indicates that significant changes have been made to the sales order lines. The results of applying the methodology to the case and the interpretation of these results are presented below.

Table 2 shows the three measures of product mix stability for each of the data sets for 1- and 2-week period lengths. The 'Original sales orders' and 'Final sales orders after changes', respectively, cover the first promised delivery date and quantity and the final after all changes have been made to the sales orders.

As expected from theory of aggregation, the product mix is more stable when the time period considered is longer [18, 24, 27]. This is seen from Table 2 when time periods of two weeks are compared, they are more stable than the product mix on a week-to-week basis.

The deviations in indicators are found by subtracting the value of the indicator for the last promised set of sales order lines from the original set. A negative value indicates more unstable behavior in the last promised set. Four out of six product mix stability indicators are more unstable in the changed sales order line set than in the original and one is unchanged. This indicates that the company through changes to promised delivery dates and quantities is facing a more unstable product mix.

Table 3 contains the values for CV_1^V, CV_2^V, CV_1^{OL} and CV_2^{OL} for the two data sets. The subscript denotes the length of the time period. Similar to the product mix, longer time periods give more stable behavior for both data sets. Similarly, the negative deviation values in Table 3 indicate that the final promised sales order lines destabilize the planning environment. From the table, it can be seen that for all counts of CV^V and CV^{OL} the original promised sales order lines give a more stable planning environment. CV_1^V and CV_2^V increased 16.2% and 28.9%, respectively, and CV_1^{OL} and CV_2^{OL} increased 33.0% and 29.5%, respectively, in the last promised set of sales order lines.

Table 5. Autocorrelation measurement for first and final data sets with different lags

Period	First data set				Final data set			
	Lag=1	Lag=2	Lag=3	Lag=4	Lag=1	Lag=2	Lag=3	Lag=4
Week 1	−0.131	0.065	−0.147	−0.256	0.212	−0.102	−0.092	−0.029
Week 2	−0.031	−0.032	−0.033	−0.013	0.418	0.310	0.335	0.253
Week 3	0.095	−0.065	0.171	0.049	0.040	−0.018	0.010	−0.146
Week 4	−0.031	−0.083	0.018	−0.008	0.452	−0.027	−0.041	0.052
Week 5	0.245	0.040	0.005	−0.015	0.210	0.006	0.016	−0.005
Week 6	−0.062	0.014	0.009	−0.041	−0.074	−0.044	0.017	−0.079
Week 7	0.082	0.137	0.039	−0.017	0.080	0.146	0.080	−0.050
Week 8	0.322	0.099	−0.122	−0.045	0.468	0.255	0.102	0.159
Week 9	−0.027	−0.024	0.003	−0.021	−0.031	−0.053	0.058	0.021
Week 10	−0.034	−0.006	0.111	0.007	0.263	0.195	−0.080	−0.139

Table 6. Pearson correlation measures between the number of changes per sales order and the three (R-, V- and OL-OTIF) delivery performance measures and their corresponding significance levels.

	R-OTIF	V-OTIF	OL-OTIF
Correlation	0.0072	−0.0162	0.0139
p-value	0.93	0.85	0.87

This strongly indicates that the company is not leveling demand over the week or bi-weekly time periods by changing delivery dates and quantities. Likewise, the deterioration in the CV^{OL} values indicates that the company will incur a larger variation in the number of setups and changeovers. This can make estimating packing capacity and the time needed for handling changeovers more difficult. In all, the volatility of both volume and number of order lines increases due to the changes to sales order lines.

Table 4 shows that the order size of final data set is more stable than that of the first data set, indicating that the company has more stable order size distributions within their weekly planning buckets.

The coefficient of variance of average weekly order size of first and final data sets are 0.701 and 0.32, respectively. This supports the conclusion that the order sizes are in the final data set stemming from more symmetrical distributions. However, it is noteworthy that these more symmetrical order size distributions have not been achieved through leveling the overall volume.

While the data presented in Table 4 indicate less variation in order sizes within the weekly time buckets, the results presented in Table 5 indicate that this has been achieved through ordering the orders, so that large orders to a higher extent follow large orders. This is indicated through only a few periods for the first data set show dependently distributed order sizes, while, the situation is different for the final data set.

With lag=1, there are 6 weeks with a high autocorrelation value indicating dependence of observations. The periods, which are not independent in first data set, are also not independent in final data set. Hence, it can be concluded that there is a trade-off between the stability and the independence of order sizes.

The final analysis is the investigation of the relationship between the number of changes to sales order lines and the delivery performance. The results of the correlation tests can be seen in Table 6 below.

Table 6 shows both the Pearson correlation measures between the changes to sales order lines and the delivery performance and the significance levels. Through investigation of whether orders with many changes have a better delivery performance than orders with no/few changes, it is possible to determine if the delivery performance is improved by accepting or instigating changes to sales orders. The results show that there is no connection between the delivery performance and the changes performed to the sales order lines. This goes for all three OTIF measures.

The conclusion is that the company is not improving its delivery performance by changing the delivery dates and quantities, that is, orders with changes to them have no statistically better delivery performance than those with no/few changes.

The overall conclusion from the application of the methodology to the case can be summarized in the following points. First, the demand faced by the company has through changes become more unstable on product mix, volume, and the number of order lines per period. However, there is a significant improvement in the order size stability, indicating that orders have become slightly better grouped from the perspective of changeovers and line balancing. There is no significant indication that the company improves their delivery performance by changing the delivery dates and quantities of their sales orders.

The conclusion must be that by implementing changes to sales orders, the case company actually instigates a more unstable planning environment. This also explains why there is no significant improvement in delivery performance for products with many changes to sales order lines. Thus the company rather than gain benefits from the changes, actually incur a more unstable situation. This must by necessity mean that the company is incurring higher than necessary operating costs [6].

Therefore, the recommendation to the company must be (if changes to sales orders is not an order qualifier / winner) to aim at not changing their sales order lines, if they wish to have a more stable planning environment or changing them in another manner than in the current setup. In the same way, assuming that all changes are based on customer change request, the information provided by applying the analysis methodology can be used in negotiations with customers to clarify to the customer the impact of changes to the cost for the customer.

5 Conclusions and further research

While the parameters product mix, volume, and order size stability to some extent is covered in manufacturing planning and control literature, it can be concluded that they have not been linked in a comprehensive framework to establish the stability of the planning environment. From the literature review, it is established that, in general, the more stable the planning environment, the lower the operating costs for the manufacturing system with a given service level. The parameters to a large extent depend on the demand faced by a company, manifested through sales orders. Thus a rational approach would be to aim at stabilizing the planning environment, a concept recognized from, for example, Lean and Six Sigma literature, by eliminating variance. The conclusion from the literature review is thus two points. First, that a stable planning environment is preferable to ensure low operating costs at a given service level. Second, that any changes made to sales orders (whether they are internally or externally motivated) should serve to stabilize the planning environment rather than destabilize it.

This paper presents an analysis methodology aimed at establishing first, the stability of a given planning environment (based on demand data) and second, at determining whether changes to sales orders stabilize or destabilize the planning environment. The methodology addresses the topics product mix stability, volume and changeover stability, and the order size stability. The methodology then links these to changes in sales order lines and to the delivery performance.

Based on the presented case and the literature review, it is concluded that the analysis methodology is in a quantitative manner able to identify the stability of the demand being faced by a manufacturing environment. The conclusion is that the methodology can be used to establish the stability of the demand faced by a planning environment. Second, the methodology can be used as part of a diagnostics framework to identify root causes for poor planning performance and link these to changes in sales orders. This means that the methodology can be used to identify whether changes to the demand situation is stabilizing or destabilizing the planning environment.

Future research will focus on testing the current methodology on data from several other manufacturing companies to enable cross-company comparison of performance and further validation of the diagnostics capability of the methodology. Furthermore, the diagnostic capabilities of the methodology will be developed towards a comprehensive diagnostics framework for planning performance.

Acknowledgement
The research presented in this paper is funded by the European Union via the EmpoSME and ValuePOLE projects, which, we kindly acknowledge. Further, we would like to thank the case company for its engaged interaction.

6 References

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0010

THE PRISMS OF MANAGEMENT[1]

Jarosław DOMAŃSKI, Wiesław KOTARBA, Tadeusz KRUPA

Warsaw University of Technology, Faculty of Management, Warsaw, Poland
e-mail: {j.domanski, w.kotarba, t.krupa}@wz.pw.edu.pl

Abstract: This article makes a contribution to the ongoing paradigmatic debate concerning management science, aiming to define more precisely its constructs. At present, within this field there is a lack of definition, of a universally accepted way of seeing reality, which results in a clear deficit in pedagogical identity. Our proposal for a new paradigm is based on three descriptors or constructs (prisms): organization, knowledge, and safety (OKS); in this model, the leading role is played by human.

The "organization" prism, in the classic sense, concerns the organization with an emphasis on the implementation of the personalistic vision of human. The "knowledge" prism includes the technical, social, and economic aspects of the collection, processing, and use of knowledge. The "security" prism is an aspect related to the identification and prevention of crises and threats to the functioning of the OKS triad as a whole.

Keywords: organization, knowledge, security, paradigm.

1 Introduction

Human activities throughout the development of the civilization of societies can be explained by human curiosity and practical activities, generated by three natural causes:

- human's gregarious lifestyle, resulting from the instinct to follow a course, the need to connect to, reproduce, and acquire new space − in other words: the ability to organize,
- the accumulation of material and cultural goods, in particular including any form of recording economic events, administrative, political, and social, and also including those concerning religion and the military, which are inherited from generation to generation and represent the transmission of knowledge concerning human's social status, rights, and skills – in other words: the need to collect and use knowledge in all its forms,
- strengthening territorial and political borders through political, economic, and military arts – in other words: the need to increase the sense of security.

The three aforementioned groups of artifacts are easily recognizable manifestations – the result of management processes that establish and maintain human in his environment.

The effectiveness of the behavioral and physical processes of human activities in the social environment, and the administrative, political, and economic domains prejudice the aforementioned observation and decision-making perspective. The prospective outcomes are the result of curiosity and practical activity. This perspective can be examined using the prisms of organization, knowledge, and safety (OKS).

These prisms, due to their ability to bring together and consolidate knowledge in the domains of the space and security of organizations, can become a holistic tool to prevent socio-economic crisis, and are in large part derived from the economic doctrines of the modern world, including Poland, as noted by Professor Elizabeth Mączyńska in an interview with Anna Leszkowska published in the journal *Science Matters* [10].

In this article, we propose to treat a triad of prisms, organization, knowledge, and safety, as key descriptors for a new paradigm in the discipline of management science, in which the leading role is played by human.

2 Toward a new paradigm of management science

Many contemporary authors have drawn attention to the lack of a widely accepted paradigm in management science. Stanislaw Sudoł [13, p. 20] agrees with the view expressed by Płoszajski [12] and Sułkowski [14], who wrote that management science is in the early stages of establishing a paradigmatic foundation.

Apart from the ongoing discussion regarding the paradigm of the science of management, there are attempts to seek out the important elements of scientific inquiry in this field.

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Clarifying the paradigm should be supported to enhance the identity and the upgrading of management science, as argued by Szpanderski [16].

There are many definitions of the concept of paradigm. In 1962, Kuhn saw a paradigm as a set of concepts and theories that define the basics of the discipline at a given time. What is highlighted, amongst other things, is that a revolutionary change in paradigm is a feature of the maturing of science. To define a new paradigm of management science, it seems appropriate to adopt Jashapara's perspective, viewing a paradigm as the "accepted way of seeing reality in the field common to a group of theorists" [5, p. 62]. However, we should supplement this with a dimension covering variation over time, as stressed by Kuhn, which in turn leads to the proposed definition of paradigm as a way of seeing reality in the field, common to a group of theorists at a certain time.

There is intense discussion around the exploration of the paradigm of management science in academic circles. Adam Szpanderski calls for the return or even the rebirth of a (new) praxeological paradigm [16]. Lukasz Sułkowski argues for a paradigm inspired by neo-evolutionism. He sees this as a "cognitively interesting perspective for management science, which brings creative breadth to the theoretical and empirical" [15]. A middle ground, although a somewhat narrower perspective, is proposed by Barabbas' clinical paradigm, which is based largely on psychoanalytic concepts [1]. Alina Kozarkiewicz seeks a management science paradigm in the taxonomies of paradigms of the social sciences, which include: functionalism, interpretivism, radical humanism, and radical structuralism [8].

Disregarding the polemical aspects of the aforementioned views, and of other proposals, it is possible only to underline the fact that they are based on the concepts of existing paradigms, proven in other areas of scientific activity, which have simply been adopted by management science.

Therefore, the results are not derived primarily from the work of researchers in management, which may hinder their widespread adoption.

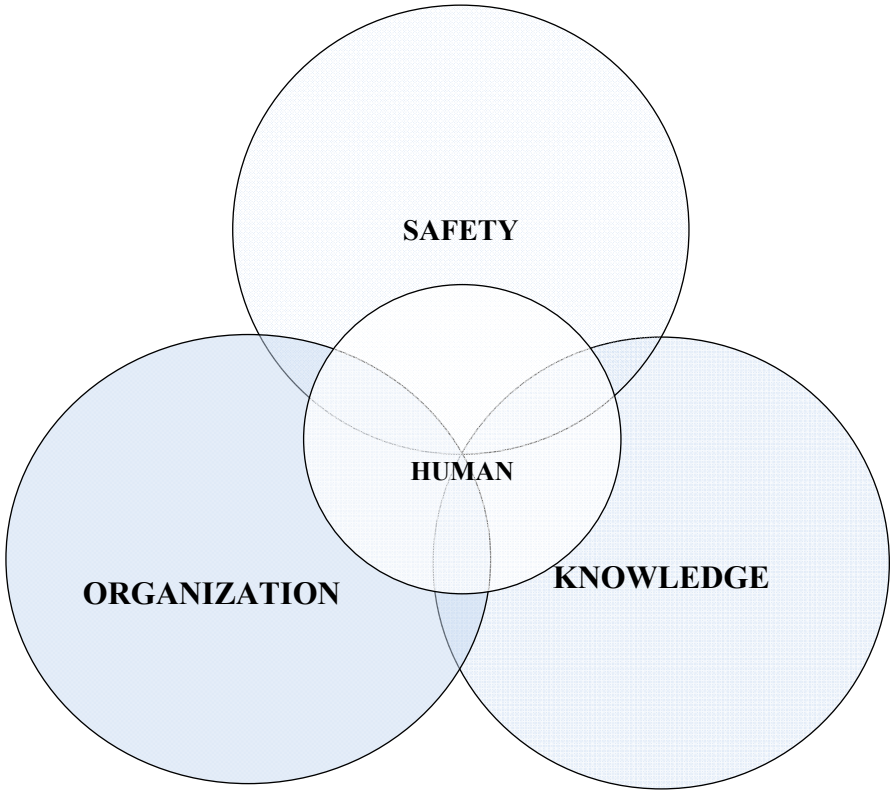

Figure 1. A schematic diagram of the new paradigm OKS
(*source: own elaboration*)

The new paradigm of management science proposed and presented in this article is based on the postulation of a consolidated perception of reality view through three prisms – organization, knowledge, and safety – taking a specific perspective in relation to observation and decision-making arising from curiosity about the world and human practical activity. Together, these prisms form a framework, the OKS paradigm, in the center of which is human. Human serves as the foundation and integrator of all the concepts, theories, methods, and tools that can be derived as the basis of the new paradigm. A schematic diagram of the proposal is presented in Fig. 1.

Human, in this paradigm, must be considered in accordance with the theory of personalization, which assumes, inter alia:

- the supremacy of human value in socio-economic considerations,
- an emphasis on human dignity, which is based on respect for the individual,
- the right to the freedom of living in truth, justice, and respect for property (including intellectual property),
- human having the scope of his responsibilities,
- the subordination of social life to the good of human.

This understanding of the role of human is consistent with the concept of personalistic leadership, which in the ontological-axiological layer is based on the philosophy of personalism, and in the epistemological and methodological layer on phenomenological methodology. According to this concept, each stakeholder should be treated subjectively; a manager should create conditions conducive to the participation and commitment of all members of the organization [2, 3].

3 The organizational prism

Organization as a prism in the proposed triad should be viewed from the classic perspective, proposed by Kotarbiński and supported by Zieleniewski, who stated: "The organization must be understood as a whole, with the components contributing to the success of the whole" [7, p. 74; 19, p. 274]. As seen by Zieleniewski, this "whole" is a system, that is, a whole composed of parts, and consideration of the whole requires consideration of the parts due to the ongoing relationship between them. In addition, these parts are to a certain extent functionally diverse, and for the whole to operate successfully, the success of each part is usually a prerequisite for the success of the whole section [19, pp. 274-275].

Taking a rather different perspective of organization and giving it new meaning in the proposed paradigm, we see it as a system that should create conditions for the implementation of the personalistic vision of human. Relationships, for example between employees, should give room for individual responsibility and be focused on respect for every person. This approach should result not only in achieving the goals of the organization, but also – and most importantly – meeting the needs of the people themselves, the stakeholders, who are part of the organization.

Thus, the ideal organization is a community of people who use their wisdom and knowledge, who respect each other, trust each other, and share common values in pursuing their own aspirations, and at the same time meeting the goals of the organization as a whole. The organization should be a place in which all stakeholders count, a place in which work is noble and dignified. First and foremost, the organization should ensure that all the people involved in it have freedom because individual freedom can provide the maximum efficiency and effectiveness of the whole. Only free men will effectively build organizations that are creative, intelligent, learning, knowledge-based, secure, socially responsible, flexible, and so on.

This way of thinking about organization is consistent with the concept of personalistic leadership, which is based on the phenomenology advocated by Max Scheler. As a fundamental principle, it accepts "moral ascent," that is it assumes that "improvement of the organization," begins with the individual, specifically the leader [3]. This links to the concept of corporate social responsibility, which postulates that organizations in the socio-economic space should not only meet the needs of the people, but also pay attention to the social implications of their actions.

Corporate social responsibility requires organizations to ensure that the positive effects of their actions are maximized and the negative are minimized. The organization seen as an element of the OKS triad, maps and links to the other prisms: knowledge and safety. It not only coexists with them, but also creates a meta-whole prism in unison with them, and it is on this that the proposed paradigm of management science is based.

4 The knowledge prism

The development of telecommunications technology, computerization, and the Internet have increased the level of education and globalization, and their attendant effects of hypercompetition, such that the effectiveness of any organization depends crucially on its intellectual capital, based on the knowledge of employees and the organization. Knowledge affects the condition of the organization, which in turn determines the type and quality of knowledge employed. The doctrine of economic sciences clearly highlights the growing importance of the development of knowledge for civilization. A rapidly growing approach called knowledge management is rightly recognized, as Kisielnicki puts it, as "a logical continuation of the trend of the development of the organization and management sciences" [6, p. 35].

Knowledge management can be assigned some of the same attributes as innovation: it is a tool of entrepreneurship and determines competitiveness. The generation of knowledge is responsible for changing an organization's current and potential state, serving to shape its intellectual capital in favorable ways.

Overall, knowledge management consists of creating, searching for, identifying, selecting, choosing, addressing (establishing flow channels, optimizing access), storing, updating, assimilating, and exploiting knowledge in such a way as to increase the value of the organization; key aspects of this process include ensuring the security of knowledge and training organizational members in knowledge management.

For knowledge management in the organization to be effective, it must be comprehensive and be part of both strategic management and operational management. It is not enough, however, to focus attention only on the technical aspects of knowledge management. Decisions taken in this dimension are not only economical and technical, but also social. The social aspects of knowledge management (and management in general) are usually associated with the social responsibility of an organization, focused primarily on issues of safety, such as environmental protection, sustainable development, and so on.

This aspect of management has recently become a subject of interest to many researchers. As a social construct, it is not only involved in the creation of intangible assets and property, but is also concerned with meeting the needs (desires) of employees, particularly in the following areas: human values, humanitarian goals, recognition, appreciation, awards, respect, justice, opportunities for improvement to satisfy ambitions, and so on. Such factors determine the quality of the work and the commitment to achieving the goals of the organization, generating a sense of community within the organization, and thus its success and wider security.

The fulfillment of human desires, within the meaning of member organizations, necessitates the organization taking actions that will result in:

- the possibility of learning, and gaining qualifications, skills, and experience,
- an increase in the ability to observe and assess creative activity, creativity, entrepreneurship, and the innovation-oriented shaping of attitudes,
- the ability to make choices and take shared responsibility,
- willingness to act and the ability to adapt to changing conditions in the internal and external environment,
- the ability to take risks and failures,
- an appropriately shaped organizational culture,
- assisting human activities through techniques and technology.

It is necessary to take into account the dynamic nature of knowledge management, which includes making new goals, and integrating new knowledge created in the organization and external knowledge coming from the environment. This knowledge must be used at the appropriate time: it must be current, select, and credible. Knowledge management involves dealing with a cyclical fund of knowledge. Observation of the knowledge cycle can promote the recognition of various areas of expertise:

- methodical (management) – structure, procedures, standards, systems for competence, leadership styles and motivation, contacts with the environment,
- technical (products and technologies for the creation of tangible and intangible assets),
- free, public, protected, concealed, and hidden (unconscious) knowledge,
- knowledge that is already possessed and that which is desirable (individual, team), used and unused.

An important aspect of knowledge is that part subject to legal protection (intellectual property).

Knowledge is increasingly becoming capital that is protected, and there is competition between organizations for this protected knowledge. In the theory of business, science, and management, organizations still ascribe too little importance to the role of knowledge management processes with regard to protected knowledge, and the effects of such processes in making an organization competitive. This is in part due to the difficulties faced by researchers in the analysis of the phenomenon of knowledge creation and the exploitation of protected assets, much of which remains a mystery, but also the lack of a tradition of dealing with this issue.

It is therefore necessary to develop and disseminate knowledge of the rules determining the relationship between the employer and employee in terms of who has exclusive rights to intellectual property, the creators of the principles of remuneration, the criteria relevant to the individual subjects of intellectual property entitling them to obtain legal protection, and the extent to which there is a monopoly on trading the property.

There is also a need to undertake research on the economic consequences of the various uses and the possible uses of protected knowledge, and the changes to the rules required to protect the knowledge in the world. Knowledge has been, is, and will increasingly become the basis for the security of the organization.

5 The safety prism

In this paper, we assume that every day human uses the prisms of organization, knowledge, and safety, but without necessarily realizing that he does so. In today's often chaotic environment, human operates in multiple triads of competing OKS prisms. He works, uses banks, utilities and insurance, health care, computer networks, databases, credit cards, transport, and engages in hobbies, forming endless sets of triads around him. Human creates triads and only human "looks" at the prisms within the triads.

Each triad is a reality (semiotic sign) and has its referent and interpretation (descriptors); each belongs to a continuous and overlapping chain of semiotic signs, showing the process of the simultaneous propagation phenomenon associated with the activity of (OKS) prisms (Fig. 2) [9].

The knowledge prism and the organizational prism together formulate the "rules of the triad" – a kind of license for the operation of human in the OKS triad.

The OKS prisms in the triads and the phenomena occurring in them change over time relative to each other in a way that is not harmonious, interfering with each other and disrupting the functioning of the triad as a whole (see Fig. 3) [9]. This can be a natural process (idiopathic), or artificial (forced), which often leads to a crisis, for example, making decisions concerning the organization under time constraints during a threat or crisis.

In essence, the process involves the breaking down of key features of organizations (socio-economic and political), and is characterized by highly dynamic changes in the structure and functioning of organizations as a result of the crisis, for example, the culmination of conflict or terrorism.

Threats – caused by the interaction of humans, material objects, or phenomena – lead to an increased risk of adverse events, and in the case of severe intensity, also to an emergency.

The membership (or share) of human in OKS triads requires significant investment. Some triads may dominate others, and some may become alienated, possibly in a process of painful self-exclusion, from the chain of triads.

The prism of human security in the multiple triads should play a dual role in the OKS formation; specifically it should:

- protect it from unwanted external domination (threats) that come from other triads (e.g., monopolies, globalization, crises, terrorism, aggression),
- protect humanity (society) from itself (e.g., global warming, consumerism, pollution, nuclear armament).

To make this possible, the OKS prisms in the triad must organize (build) safe infrastructure, create and gather knowledge about potential risks, and develop and implement safety theory – all this to ensure the continuity of business and existence of human societies [18].

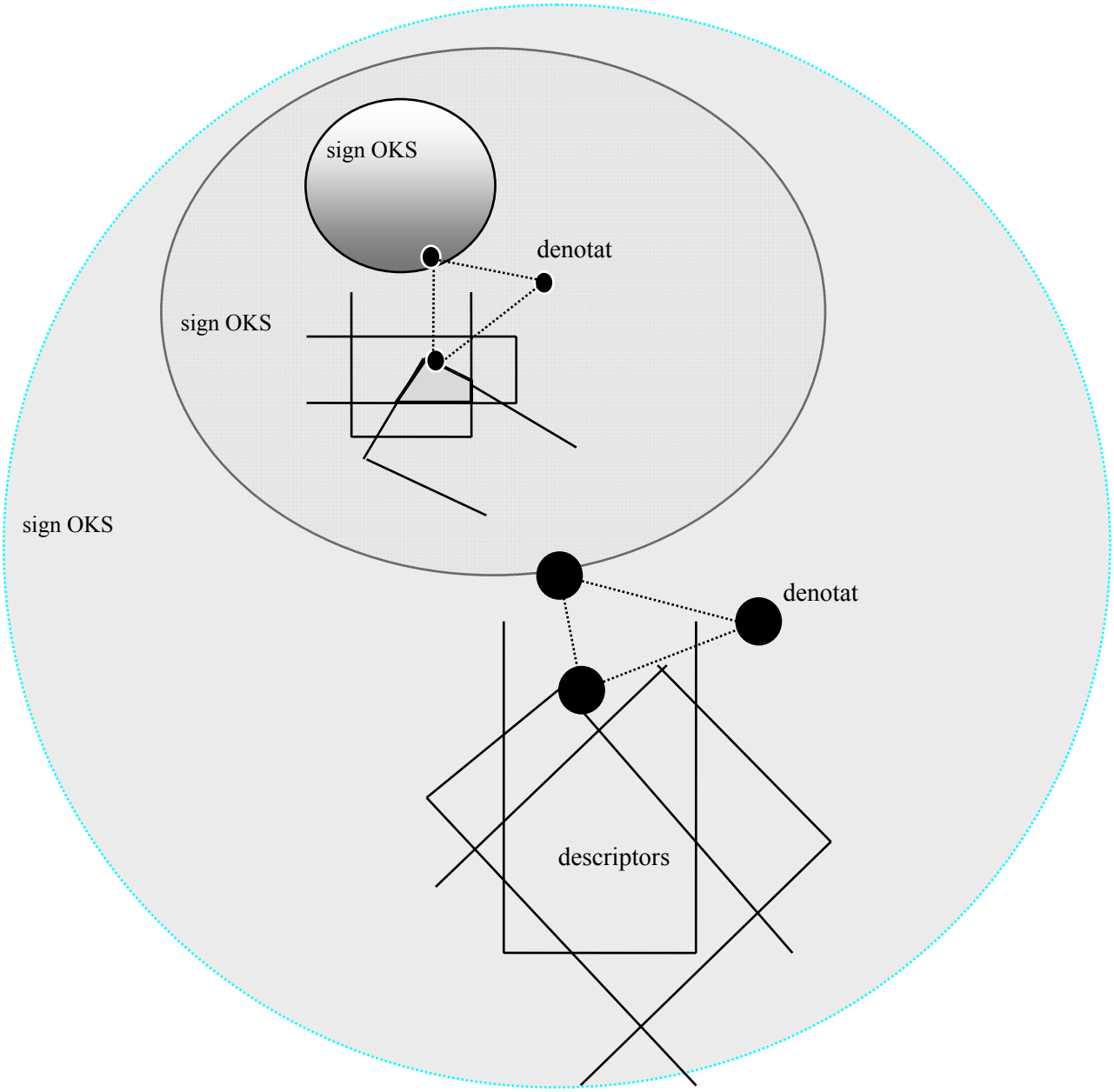

Figure 2. Continuous triads of prisms: **O** denotes organization, **K** denotes knowledge, **S** denotes security as semiotic signs; signs from the lower (deeper) levels of interpretation are treated as factual reality at the higher levels of interpretation (*source: own elaboration*)

The intellectual and physical potential of the OKS triad should be focused on diversity and the diversification of any activity, based on a philosophy of safety, employing theoretical knowledge and educating citizens concerning risks and risk management – this goes all the way up to the critical infrastructure of the security systems that are the responsibility of the state.

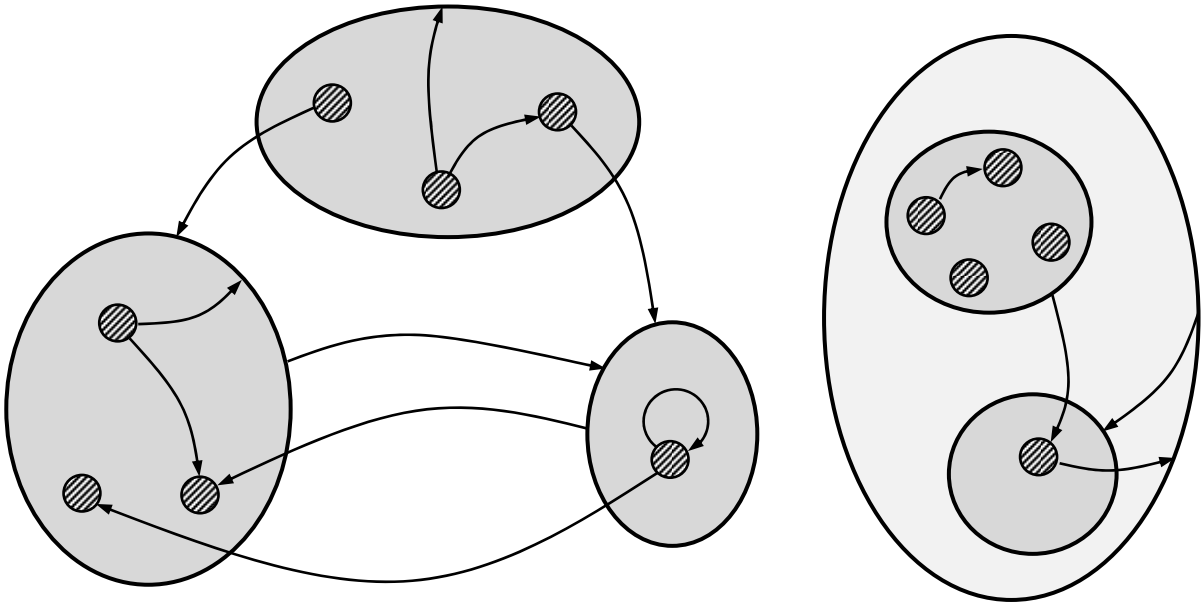

Figure 3. Examples of hypergraph models of interaction clusters; hypergraph arches combine OKS triads, pointing to external and internal interactions (threats) at different levels of their operation (*source: own elaboration*)

6 Conclusions

Management is a process carried out by human, understood in terms of the theory of personalism. The management process is the result of three artifacts (lifestyle, use of knowledge, and a sense of security), which define virtually every human activity. The effectiveness of management should be created and viewed through prisms: organization, knowledge, and safety (OKS). These prisms are, in our opinion, the key descriptors of a new paradigm in the discipline of management science:

- The organizational prism should be interpreted in classic terms, as the organization including the realization of the personal vision of human.
- The knowledge prism includes technical and social and economic aspects of the collection, processing, and use of information and knowledge.
- The safety prism is related to the identification and prevention of crises and threats to the functioning of the triad as a whole.

It is in the interests of human to maintain the dynamics of change in the OKS triad, ensuring a balance, and establishing or going beyond the boundaries of the formation of the paradigm developed by the authors of this article.

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0011

IS SUSTAINABLE DEVELOPMENT AN ISSUE FOR QUALITY MANAGEMENT?

Małgorzata JASIULEWICZ-KACZMAREK

Poznan University of Technology, Faculty of Engineering Management, Poznań, Poland
e-mail: malgorzata.jasiulewicz-kaczmarek@put.poznan.pl

Abstract: In recent years, sustainable development strategy for enterprises has become an important issue around the globe. This requires the organization to review its current systems to improve the overall triple bottom-line performance (i.e. economic, environmental, and social). Rising to these challenges requires transforming management system towards sustainable management. Assuming quality management (QM) impact on organisations will continue, what types of QM-based improvement initiatives will develop in the future to meet the anticipated organizational and market changes?

Keywords: sustainable devepolment, quality management, sustainable quality management, customer, stakeholders.

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1 Introduction

Since the end of the 1980s, as a result of the report "Our common future" published by the World Commission on Environment and Development, politics, economy, and science have been dominated by the term "sustainable development" (SD). In the report, SD was defined as a process of change in which exploitation of resources, new investments, concentration on technology development, and institutional changes are focused on present and future needs of society. At the macro level, a model of economy based on the concept of SD assumes appropriate and conscious forming of relations between economic growth (economic aspect), commitment to environment (environmental aspect), and quality of life (social aspect). For a company (micro level), SD means adoption of such business strategy and such actions that contribute to satisfying present needs of company and its stakeholders, as well as simultaneous protection, maintenance, and strengthening of human and environmental potential that will be needed in the future [68].

These new challenges are accompanied with a growing focus on the role of the quality management (QM) approach. The question then arises: is SD an issue for QM? As is well-known, the framework of quality has constantly evolved in accordance with environmental changes, and due to the absorbing and adaptable capability, the quality approach has "received" many new names.

This paper aims to address the issue of QM in today's turbulent environment. To answer the question asked in the title of the this paper, the paper is structured as follows. In the second chapter, the idea of SD is characterized. The term "sustainable development" is defined, challenges of the approach are introduced, both at the global and operational level, and strategies for the integration of SD into business processes are presented. In the third chapter, the idea of QM is characterized. Evolution in approach to QM is discussed and features characterizing each stage of QM development are listed. In the fourth chapter, common elements of both approaches: SD and QM are identified and analyzed to define issues of SD referring to QM. The new stage of QM development was called Sustainable Quality Management, as it increases the range of isuues that should be considered when shaping QM system in a company. Sustainable quality management provides a potential to improve and extend the theory generation and the best practices of QM in the future. The fifth chapter is a summary. The important area of the research conducted is analysis of range of sustainable management practices reaching beyond an organziation.

2 Sustainable development

2.1 SD definition and issues

The origin of the English word *sustain* is in the Latin words *sub* (under, from below), and *tenere* (to hold, to hold up). To sustain, then, means to keep up, to maintain, to support, to prevent from sinking or falling something. Sustainability is the ability to maintain or support an activity or process over the long term [10]. In the context of human development and environmental stewardship, the term sustainability has ideological, political, ecological, and economic contexts and, in this framework, it is most commonly seen as a derivation of the term SD [62, 12].

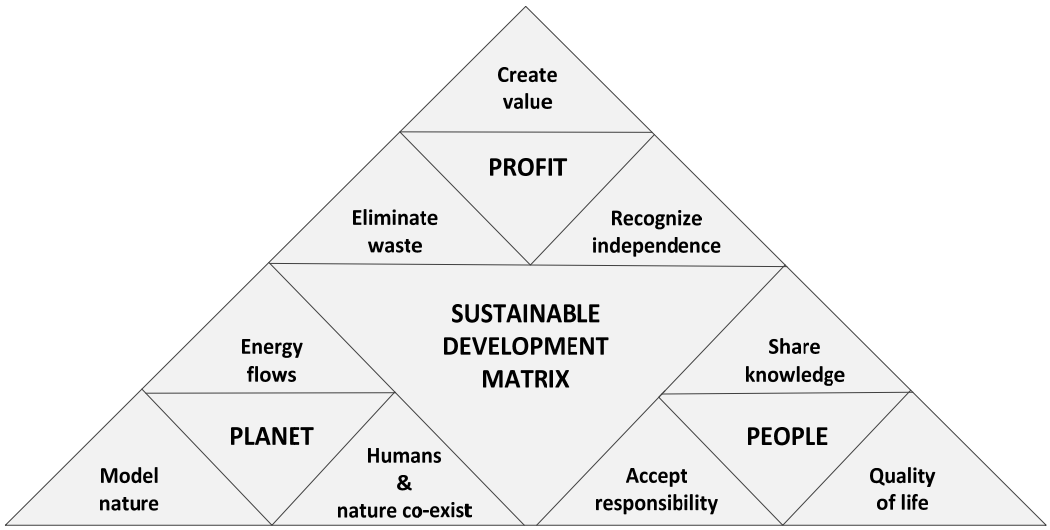

Figure 1. 3P's model (*source: [52]*)

The term SD has different meanings to different people and has numerous interpretations. One of first and most cited definitions of sustainability was created in 1987 by the Brundtland Commission, which defined SD as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (…) "Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs" [75]. Thus, SD is about reaching a balance between economic, social, and environmental goals, as well as people's participation in the planning process in order to gain their input and support [69]. Sometimes SD is referred to as a triangular theory, reflecting the triple bottom line: social, environmental, and economic criteria; terms like; 3P's – people, planet and profit (see Fig. 1) or even 3E's – equity, environment, and economy [77].

Szekely and Knirsch [73] defined sustainability as creating a proper balance between economic, social, and ecological aims. They believe that for businesses, this includes sustaining and expanding economic growth, shareholder value, prestige, corporate reputation, customer relationships, and the quality of products and services. By Robert W. Kates *et al*. [41], SD is defined through goals, indicators, values, and practice. The British Standard on sustainability management defined SD as "an enduring, balanced approach to economic activity, environmental responsibility, and social progress" [9]. This definition makes two fundamental points: first, that SD necessarily considers social, economic, and environmental aspects together, and second, that options for the future should not be limited. An important practical implication of this is that tackling any of these issues in isolation can result in unintended consequences along other dimensions. Decisions must be taken in a way that integrates all these concerns, and this means taking into account the concerns of stakeholders from outside the organization as well as within it.

Analysis of the definitions presented above leads to the conclusion that SD requires:

- a broad view of social, environmental, and economic outcomes;
- a long-term perspective, concerned with the interests and rights of future generations as well as of people today;
- an inclusive approach to action, which recognizes the need for all people to be involved in the decisions that affect their lives.

SD is a process on the way to a crucially important goal: sustainability. Achieving sustainability requires supporting action from all sectors of society, including business.

2.2 Corporate sustainability

SD requires the contribution and involvement of many actors. Companies are important players, as they influence the natural environment and society with their product designs and offers, their production processes, purchasing decisions, and their business models [18].

SD therefore requires companies to get actively involved in shaping and implementing sustainability measures. The objective of SD confronts business enterprises with three sustainability challenges [66]:

- ecological challenge: increasing ecological effectiveness,
- social challenge: increasing social effectiveness,
- economic challenge to environmental and social management: improving eco-efficiency and/or social efficiency.

Enterprises must manage all these conflicting aspects of sustainability in an integrated manner, focusing not only on environmental or social performances, but also on sustainability of business.

And what does the term "sustainability" mean for an enterprise? According to Grudzewski and Hejduk [25], *Sustainability* is the capability of an enterprise to continuously learn, adapt and develop, revitalize, reconstruct, and reorient for maintaining solid and distinctive position in a market by offering extraordinary value for buyers, today and in the future (according to paradigm of innovative growth), thanks to organic changeability constituting business models and emerging from creating new opportunities and goals, as well as answering to them, with balancing interests of various groups. (...) *Sustainability* is based on the following principles: holistic, and continuously developing view of reality, reflections, cooperation, openness to changes, learning, and trust". According to Sidorczuk-Pietraszko [68], for a company SD means adoption of such business strategy and such actions that contribute to satisfying present needs of the company and interested parties, as well as simultaneous protection, maintenance, and strengthening of human and environmental potential, which will be needed in the future. Zairi [76], defined sustainability as the ability of an organization to adopt to change in the business environment to capture contemporary best practice methods and to achieve and maintain superior competitive performance.

Pojasek [57] believes that the problem with these definitions is that it is difficult to make operational. To help people understand how to put sustainability to work, he would propose the following as a starting point for creating a definition: "Sustainability is the capability of an organization to transparently manage its responsibilities for environmental stewardship, social well-being, and economic prosperity over the long term while being held accountable to its stakeholders" [57]. This definition of sustainability requires each organization to act responsibly. So it is up to the organization to determine what constitutes responsible behavior, and then manage its actions so that the responsibilities are practiced.

As SD has become the basic factor of competitiveness for many manufacturing enterprises worldwide [20, 36, 26], the need exists to operationalize the approach. Hence, the question arises: how to integrate SD into business processes and everyday routines?

A number of authors have discussed the strategies for the integration of SD into business processes. Review of literature on the subject provides recognition of the three groups of strategies:

- approach based on international and national standards,
- approach based on business excellence models, and
- other approaches, benefiting from various elements of various management ideas.

The first group includes approaches based on standards developed by International Standardization Organization (ISO) [13, 56, 27]. The ISO has developed a number of standards related to the management of SD. The standards most often presented in the literature are:

- ISO 26000:2010 "Guidance on social responsibility", which provides guidance on how businesses and organizations can operate in a socially responsible way, it is a guidance rather than requirements, so it cannot be certified to unlike some other well-known ISO standards,
- ISO 20121:2012 "Event sustainability management systems Requirements with guidance for use", which provides the framework for identifying the potentially negative social, economic and environmental impacts of events by removing or reducing them, and capitalizing on more positive impacts through improved planning and processes,
- ISO 14001:2004 **"**Environmental management systems Requirements with guidance for use", which provides practical tools for companies and organizations looking to identify and control their environmental impact and constantly improve their environmental performance.

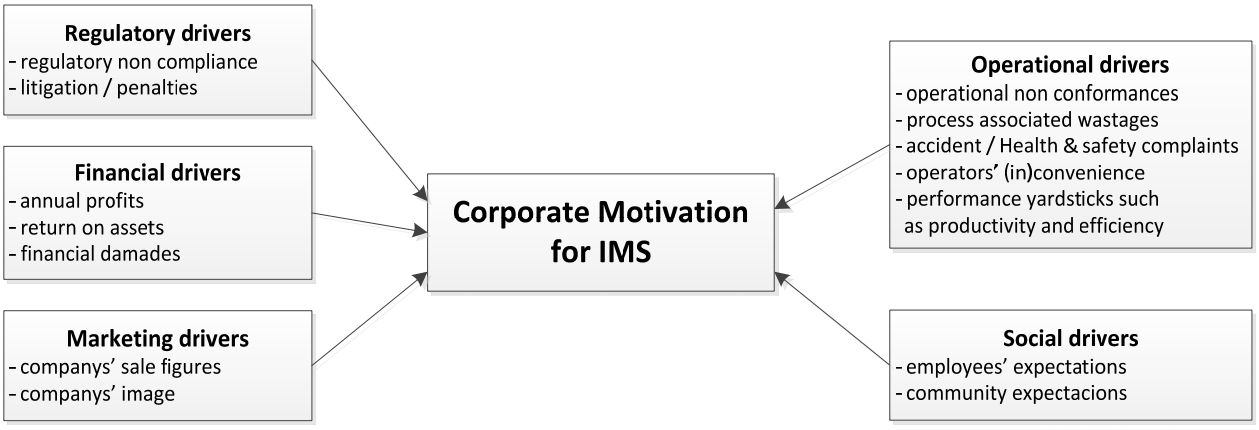

Figure 2. Model of corporate motivation for IMS implementation (*source: [1]*)

Guidelines and standards have also been developed within individual countries to meet local needs, for example, guides developed by British Standardization Institute (BSI):

- BS 8900-1:2013 "Managing sustainable development of organizations Part 1: Guide", which provides guidance on managing SD and a framework that assists organizations to enhance performance and effectiveness,
- BS 8900-2:2013 "Managing sustainable development of organizations. Framework for assessment against BS 8900-1. Specification", which acts as an evaluative framework to support organizational self-assessment or third-party assessment and result in formative outcomes.

Several papers have focused on an integrated management systems approach to SD. Enterprises which implemented several various management standards often integrate them into one coherent management system, and factors driving integration process include: regulatory drivers, financial drivers, social drivers, etc. (see Fig. 2).

Integration of management systems such as for quality, environment, occupational health and safety, risk management, and corporate social responsibilities is a viable organizational approach to cost reduction, efficient utilization of resources, greater motivation of employees, and better compliance with social obligations and stakeholders' requirements [40, 37, 61, 38 and 2]. In the context of SD, based on the Brundtland definition of SD, companies are asked to manage resources in such a way that we do not impair the possibility of future generations to satisfy their needs. This means that the future generations as customers, society and employees also are stakeholders. Developing integrated management system enables including requirements and expectations of various stakeholders and enables various stakeholders to facilitate IMS development [35].

The second group includes the approaches in which basis for the implementation of SD are business excellence models, such as the European Framework for Quality Management (EFQM) and the Baldrige Criteria for Performance Excellence [7, 3, 11]. The possible linkages between corporate SD and the EFQM are further highlighted by Isaksson and Garvare [29]. As these authors have shown, the EFQM could provide a starting point for the integration of sustainability into business processes. While it is a potentially useful starting point, the EFQM does not provide a comprehensive model for organizational sustainability [4].

The third group includes the approaches benefiting from various management methodologies, standards, and good practices, e.g. codes. The interesting example of a solution within the group is a model developed by Asif & Searcy [4], so-called Sustainable Development Management System (SDMS) model. According to Asif and Searcy [4], "The systematic implementation and assessment of corporate sustainable development is difficult in the absence of a structured approach. The existing management systems and frameworks do not provide a balanced approach to the management of the triple bottom line of sustainable development." Reaching out to the need of business environment, they developed SDMS, described its elements (Table 1), developed the model (Fig. 3) and defined standard requirements for management systems in Plan-Do-Check-Act (PDCA) cycle context.

Table 1. The core descriptive elements in a SDMS
(*source: [4]*)

SD core values	Characteristics
Stakeholder-oriented management	The concept of sustainability is centered on the need to address stakeholder requirements in a systematic and integrated manner
Triple bottom line	Organizations need to understand the social, environmental, and economic implications of their business. The measures should be taken to ensure that business processes of an organization do not adversely affect these three bottom lines
Systematic approach	Organizations need a systematic approach to the management of SD. A systematic approach is reflected in the: • management by facts, • a focus on results and creating value, and • a systems perspective on managing SD
Strategic management	SD needs to be addressed strategically through the visible commitment of top management. The tactical processes and operational activities need to be aligned with the organization's strategic priorities
Innovation and learning	Organizations need to ensure never-ending improvement, innovation, and learning along all dimensions of stakeholder requirements

SD: Sustainable development

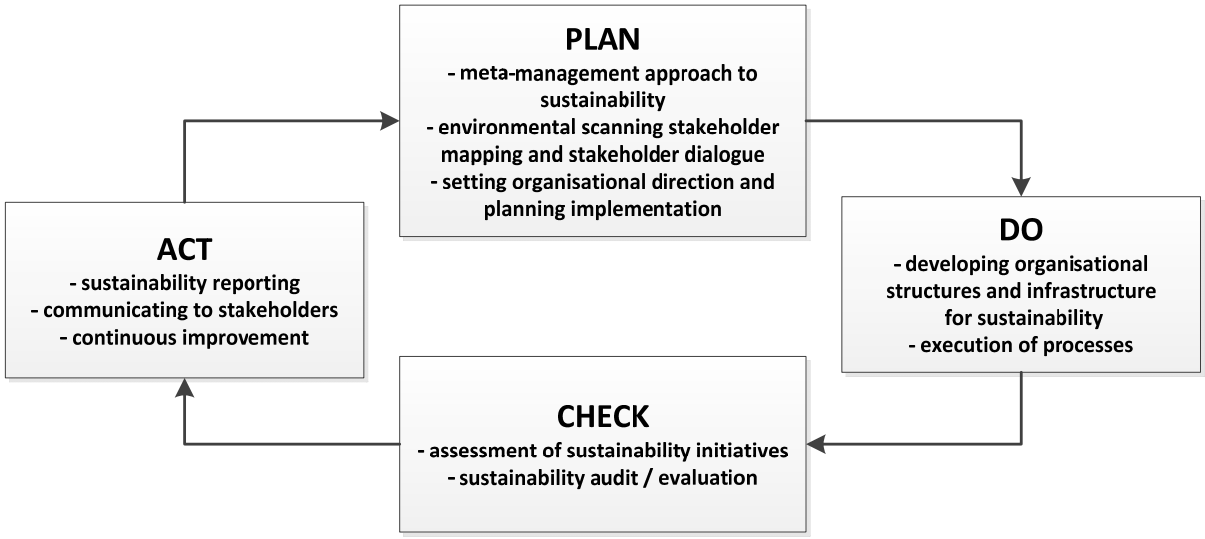

Figure 3. Management of organizational sustainability based on the PDCA cycle
(*source: [4]*)

According to authors, the PDCA-based structure of the SDMS makes it possible to integrate it with other standards, including ISO 9001, ISO 14001, OHSAS 18001 and other specification standards.

Summarizing, the approaches presented above interchangeably show that implementing SD into business processes requires strategic approach, including commitment of top managers, incorporating SD into vision and mission of a company, as well as setting principles and practices at all the levels of organization. Boechat *et al*. [6] identified three dimensions, which are essential in translating sustainability issues into strategic priorities for firms and managers:

1) Identify strategic sustainability issues – a material concept of sustainability, must be understood in order to define risks and opportunities and their relation with the firm's business strategy, transforming them into a source of competitive advantages.

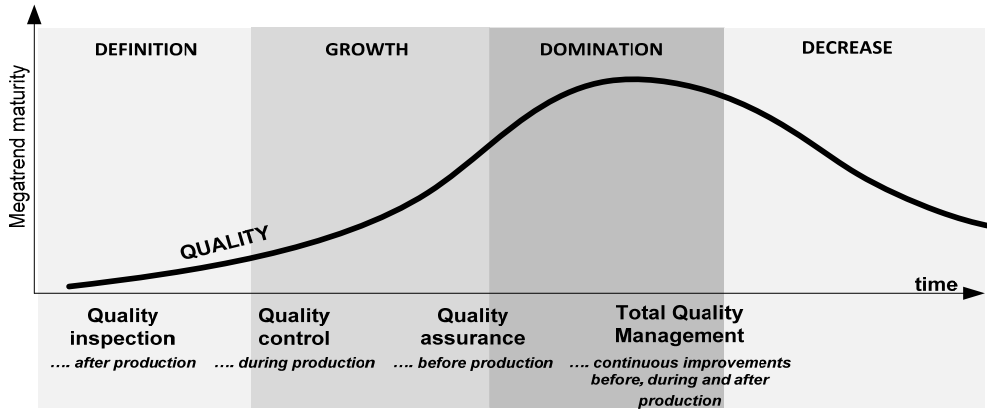

Figure 4. Life cycle of a mega trend "Quality"

2) Cascade strategic priorities in supply chain – engage supply chain partners in order to leverage financial, social and environmental performance.
3) Involve corporate departments and corporate functions – promoting sustainability in a company has to be a process that is shared amongst its different business units. Only once each unit identifies its most relevant activities will their consolidated impact benefit a company´s triple bottom line performance.

The success of a SD process depends, above all, on the quality of the process by which it is realized. SD is not a property and is not a fixed state of constancy but a process of directional change by which a system improves through time in a sustainable way. SD is a learning process. This continuous improvement process should slowly but surely be integrated into existing company structure and procedures.

Taking into account the fact that the approach which acts the longest at the operational level and confirms its effectiveness in many organizations worldwide is QM, the question arises whether SD issues could be effectively operationalized by including them into QM system functioning in an enterprise.

3 Quality management – from reactive to proactive approach

Similar to sustainability, quality is a broad, multi-interpretable, relative and dynamic concept. Many ways of defining and interpreting quality term in utilitarian sense refers to the level of noticing and range of problems it contains in a company. According to L. Wasilewski [74] "if for any reasons we have to define the term quality, we have to adjust it to the level of system development in a company. (...). As their quality system is developing, companies change main dimensions of quality definition and measures they use". Such evolutionary character of the tem quality can be found in scientific works of [16, 28 and 44].

D.A. Lubin and D.C. Esty [49], defined actions undertaken in companies to achieve quality as one of mega-trends in management. The term "mega-trends" was coined and popularized by John Naisbitt in 1982. He defined mega-trends as broad processes embracing the world, having socio–economic or structural character and influencing a unit and shaping its future [54]. Broader definition was introduced by [70], as they defined mega-trends as "global, solid and macroeconomic development forces, which influence business, economy, society, culture and private life and by that defining our future world and its growing pace of changes".

Development of "mega-trend" can be presented in the form of a product life-cycle model, with four specific stages [62]:

- stage 1 – Definition, which is convergence of trends connected, leading to creation of mega-trend
- stage 2 – Growth, which is fast manifestation of mega-trend and spreading its influence on business, industry and lifestyle.
- stage 3 – Domination, the stage refers to the results of mega-trend and its influence on all the areas of social and economic life.
- stage 4 – Decrease, which is a period in which mega-trend is so common that it is treated as a normal thing.

In the following paper, the following approaches to "quality" mega-trends analysis were applied (see Fig. 4).

The first stage of QM development is quality inspection. It originates in XIX century, as then because of industrialization, mass production, specialization, and work division became the leading paradigms [43]. At this stage, quality was mostly connected with products and the focus was on inspection of some critical characteristics of final products referred to predefined requirements – specifications. The goal of the inspection was identification of final products not meeting requirements specified, and afterwards, if possible implementation of corrections, and if not selling products at lower prices. The main task of managers in an enterprise was keeping efficiency at the high level, while quality inspection was performed by inspectors trained and representing pre-formed quality departments, so production staff was not involved. Along with economic development and production scale growth, inspection costs have been growing and did not give the results expected by the owners. It was noted that by inspection it is impossible to provide an appropriate level of quality [53].

The scope of activities charged with quality started to extend the processes of production. This stage of development and the perception of quality in the company in the literature is called quality control. By contributing to the quality employees were included in the production, drew attention to the skills of workers supervised by them formally established requirements and standards for their implementation. Feedback was created between the result of control and production line.

Based on the results of checks, production process was modified so as to obtain products that met the specifications. As in the run-up, the producers did not have much difficulty in disposing of the products, and therefore did not have to take into account customer feedback. During this period primarily refined receiver subsystems and supply the current and final product inspection, not paying attention to the information coming from the market. Producer's market caused that customers were forced to accept conditions defined by producers. Whereas customers were interested mostly in access to products, their quality was of a secondary importance. Dissatisfaction of customers, if appeared, was mitigated by replacing or repairing defective products.

Summing up. In the first two stages of QM development, actions were focused on detecting discrepancies and taking up reactive corrective actions. The thinking was departmentally based and did not usually directly involve suppliers or customers.

The central idea in the quality assurance (next stage) is that quality of output can only be achieved by organizations that are in control of their processes and functions, and that try to continually improve themselves. This stage, directs organizational efforts towards planning and preventing problems occurring at source. Emphasis is shifted from mere detection to training, product design, process design, process control and motivation of people. Factors creating product quality were taken into account, even if they were not directly connected with manufacturing area – but a part of pre-production and post-production processes. In pre-production, the stress was put on materials and sub-assemblies deliveries, suppliers qualification procedures, requiring implementation of pro-quality solutions by suppliers, so that they covered the entire manufacturing process. In post-production area, pro-quality actions included improvement in post-sale services, creating premises for embracing the entire product lifecycle. The next step in striving for providing products of quality was adjusting organization to quality requirements defined by customers and users of products and services. The postulates emerged for developing solutions which would embrace in systematic way requirements necessary to achieve quality expected by customers. The first system-based solutions, including the entire nets of co-operational requirements, were developed in the USA (f.ex. MIL-Q-9858). In Europe, the earliest interest in the field was in the Great Britain. In 1972, BSI published BS4891standard – "A guide for providing quality". Soon, other European countries followed the Great Britain. Internationalization of economic exchange and variety of requirements included in national standards led to necessity of coordinating normalization actions and taking up development of systematic international solutions. In 1987, the ISO published the first edition of its 9000 standards.

From the very beginning, the standards were classified as so called third-generation standards, which means they are completely different from industrial standards, focusing f.ex. on product's characteristics. Thus, their basic assumption was the idea of standardizing general methodologies of managerial practice, bringing benefits to both, suppliers and customers [43].

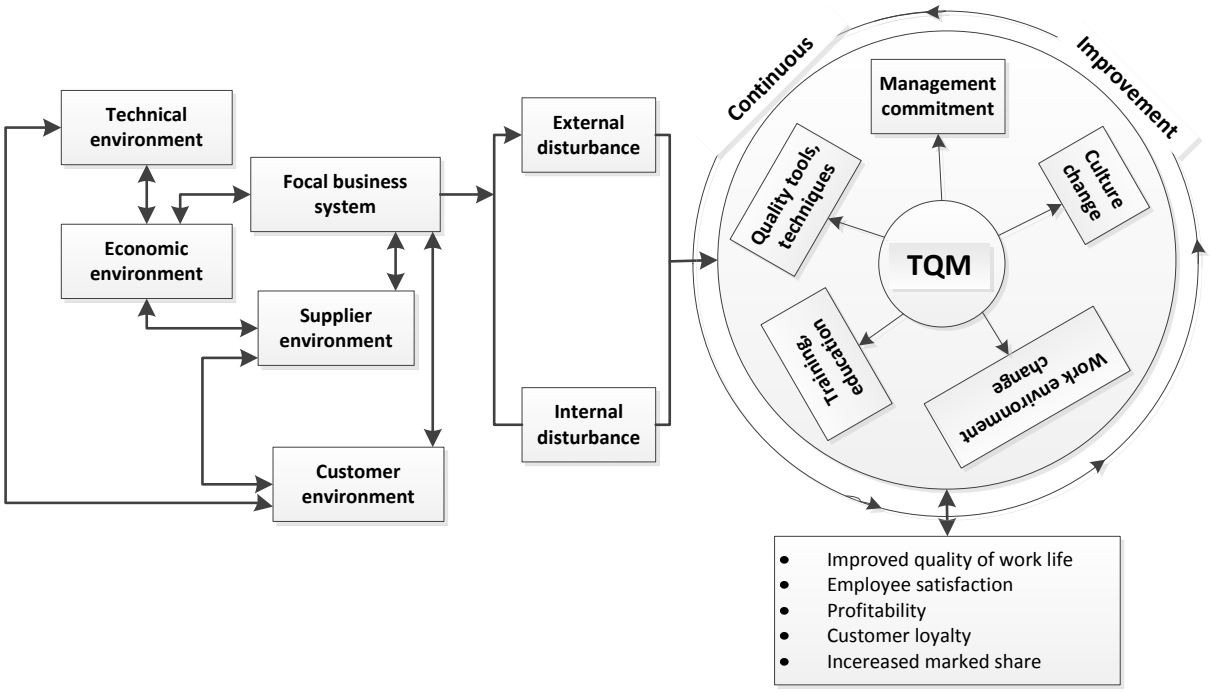

Figure 5. Effect of Interactive Environment on Business System
(*source: [45]*)

The fourth stage, can be described as total quality management (TQM), where quality has become a strategic issue and its scope extended to the quality of the organization and the quality of the relationship with the environment of an organization (customers, suppliers, competitors, the public in general) and their integration with horizontal business processes [8]. This paradigm states that the responsibility for quality lies not with one department or one person (the representative of the management), but the whole organization needs to take responsibility for quality and take it as a common value [55]. The objective of TQM as suggested by Lakhe & Mohanty [45] is to identify and recognize the external environment (i.e. supplier environment, customer environment, economic, and technological environment) and create conditions within the focal system to maintain internal balance and eventually gain external equilibrium (see Fig. 5).

TQM is multidimensional approach analyzed in the following aspects, that is: strategic, marketing, technological, economic, organizational, social, and system-based [72]. Various interpretation of TQM approaches is a results of taking various definition criteria (Table 2).

Table 2. Various TQM interpretations
(*source: [72]*)

TQM definition criteria	Characteristics
In activity-based approach	TQM is a process, its strategic market goal is increase of competitiveness and company's value
In operational approach	Goal of TQM is achieving desired size and structure of results of actions undertaken by a company
In objective approach	TQM is an approach of corporate management that strives for meeting requirements and expectations of customers
In subjective approach	Refers to all the employees of an enterprise, hence it is dedicated to both, managers and their subordinates
In functional approach	Refers to all the areas of economic activity, together with interdependencies involved

TQM: Total quality management

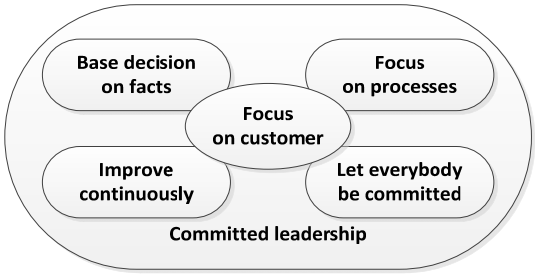

Figure 6. The core values of TQM
(*source: [28]*)

TQM may be defined as a continuous quest for excellence by creating the right skills and attitudes in people to prevent defects possible and satisfy customers/users totally at all times [45]. Hellsten & Klefsjö [28] defined TQM, as a continuously evolving management system consisting of values, methodologies and tools, the aim of which is to increase external and internal customer satisfaction with less resource consumption.and introduced core values, which should be used to characterize this approach to quality in an enterprise (Figure 6).

Praxiom Research Group Limited (2003, cited by [59]) defined TQM as a management approach that tries to achieve and sustain long-term organizational success by encouraging employee feedback and participation, satisfying customer needs and expectations, respecting societal values and beliefs, and obeying governmental statutes and regulations. Independently from the level of precision in TQM definitions presented in the literature, there are some common elements of TQM stressed, namely: top management commitment, everybody's commitment, continuous improvement, focus on customer, focus on process, and using facts-based approach for decision making.

Research on the literature related to the subject shows that the successful implementation of TQM can lead to a wide range of benefits for organizations. These benefits include higher profits, growth and efficiency, increased market shares, reduced operational cost, productivity, and innovation [45, 33, 14, 63 and 47].

Nevertheless, because of the lack of generally accepted universal TQM model, many companies "turn back" from the approach searching for improvement guidelines in quality awards and models [64, 42]. Confirmation of the pre-mentioned "turning back" from that approach to management is TQM application tendency observation. Whereas in 1993, TQM was applied in 72 % of analyzed companies, in 2000 the number fell down to 41 % only, and in 2008 the number reached 34 % [60]. It is on hand the result of a "fashion" (the term "quality" is a bit old and out-of-date compared to fresh and nowadays catchy "excellence"), and on the other the consequence of the situation that the criteria of the original quality awards (e.g. EFQM, MBQA) successively over the years widened their perspectives in harmony with discussions related to environmental issues and social responsibility.

Edited in 2000, the next version of ISO 9001:2000 standard adopts TQM philosophy with stronger focus on customer satisfaction and an effective process-oriented approach, emphasizing on continual performance improvement (in 2008 there was the next amendment; however, no important differences compared to previous editions were introduced). In the standard, the stress is put on the fact, that organizations depend on their customers and therefore, should understand them current and the future need; they will meet these requirements, while taking care to exceed customer expectations. "Quality" is delivering an output meeting or exceeding customer's expectations. The client is the frame of reference for answering the question "What is quality?", including the nature of quality as well as the needed or appropriate level. This new revised standard is a step forward towards TQM, customer satisfaction and does not just achieve product quality assurance.

Summing up. The third and the fourth stage of quality mega-trend development indicate that there is a substantial change in approach to quality. The models presented above are oriented neither to a given product, service nor quality control methodology, but to broadly understand corporate management and processes influencing final products.

What then is to be the next stage in the evolution of QM after TQM. As we have seen, TQM has been characterized by strong focus on the following issues:

- espoused organizational values supported by methodologies and tools,
- customer focus and satisfaction,

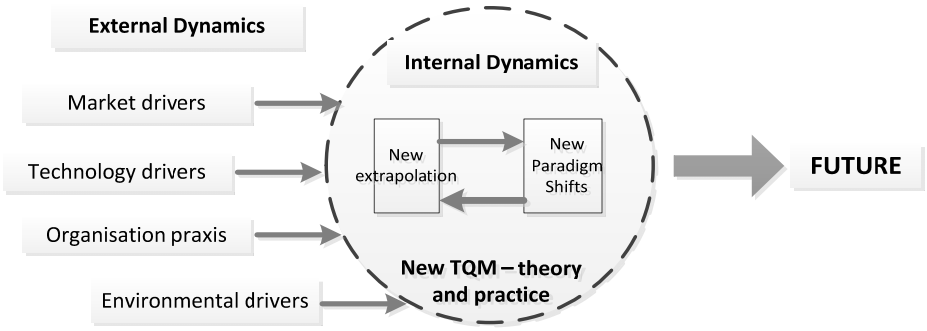

Figure 7. Model of internal and external TQM drivers
(*source: [50]*)

- efficient use of resources,
- continuous monitoring and assessment of improvement potentials.

What will be its characteristics and focus in the future?

4 Sustainable quality managemant

Searching for answers to questions presented in the previous chapter, requires referring to the model presented in the figure. Nowadays, we are at the fourth stage of the cycle. It means that "quality" megatrend is in its decreasing stage, hence it is the "normal" approach from the company's point of view. However, assuming that QM impact on organization will continue, question on the types of QM based improvement initiatives that will develop in the future to meet the anticipated organizational and market changes seems to be justified. And even though because of increasing complexity, discontinuity and pace of changes, future forecasting is almost impossible, we still can and should try to forecast future. Identification of direction that QM will evolve in, is valuable in cognitive and utilitarian sense. It is to enable the understanding of external challenges, which are unavoidable, and make developing scenarios easier by providing guidelines useful in decision on shaping QM system in companies making process.

Future QM in a company will be shaped by two kinds of factors (Figure 7): external, which refers to changes in business environment, and internal, which refers to issues within QM movement.

External factors, which currently most influence company's functioning and the way its strategy is shaped, are challenges brought by SD. SD is the next megatrend in management [49]. Through the next years, this trend will shape trends and force sustained changes in methodologies of actions taken and building competitive advantage of companies. Thus, organizations should identify the trends, assess their influence on its activity and opportunities it creates, and include and integrate them to binding business strategy.

Analysis of both approaches presented, SD and quality [34], leads to the conclusion that they have much in common:

- Both have gone through a historical and conceptual progression from passive reactivity to proactive, strategic integration. Over the years, quality issues have evolved from being focused on product performance to comprehensively addressing business excellence. Similarly, SD for many years was associated with environmental aspects and degradation of natural environment caused by civilization development only, while now it is a broad concept referring to such terms as "quality of life" and "corporate social responsibility".
- Both impact satisfaction, well-being and safety of customers, employees and other stakeholders. In QM, customer focus has evolved into the broader concepts of interested parties, human stakeholders, environmental stakeholders and societal sustainability [24].
- Both are based on a core set of values, such as "create zero waste," "make external costs visible," and "drive out fear" between management and employees [71]. Like quality, SD also has a strong focus on people – not just in terms of customer satisfaction, but related to the quality of working life and employee satisfaction.
- Both impact, and are impacted by, every function in the organization. Just as a customer's perception of quality is affected by everything including product design and development, manufacturing, logistics, interactions with marketing, sales, customer

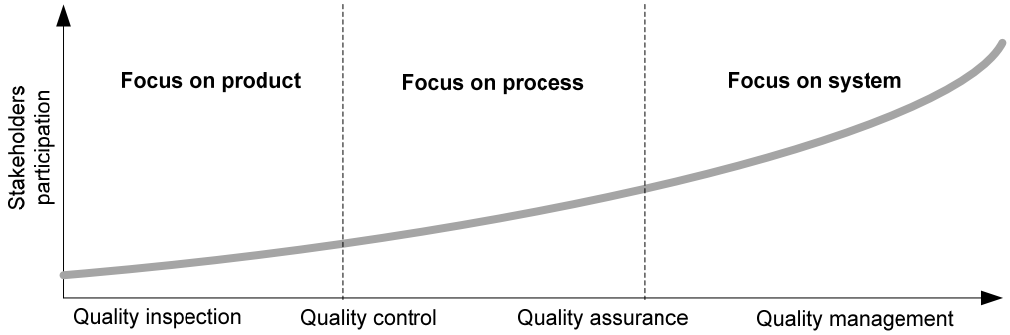

Figure 8. Stakeholders' participation in quality approaches

service and more, so too is sustainability impacted by every function within the organization. Like sustainability on the societal level, the SD of a company requires the involvement of a variety of company-internal actors, since many challenges of sustainability management demand the contribution of several corporate functions [66]. The involvement of all functional units is considered to be necessary to create comprehensive sustainability solutions and to impede sustainability problems from being partially or superficially "solved" or from being shifted back and forth between functional units [67].

- Both are based on continuous improvement towards a performance ideal: a company will never reach perfection in either quality or sustainability, and it is also never "done," but rather always striving to improve towards the goal of perfection.
- Both, if done well, help drive significant financial and strategic benefits to the organization in the form of scrap and rework reduction, cost reductions, increased profitability, improved reputation and customer loyalty.
- In both, senior management holds complete responsibility. The majority of quality problems are the fault of poor management rather than poor workmanship. Likewise, corporate sustainability success is directly related to CEO commitment. Value creation is driven through executive buy-in and execution throughout the organization [46].

Taking into account challenges brought by SD to managers (see chapter 2) and common elements of both mega-trends introduced above, it is clear that the important element of each stage of evolution of QM is "transactivity" term, which lies at the basis of link between organization and its broader social context. The term is a key relation between QM idea, and the idea more and more important, that is corporate social responsibility; moreover, it is an attempt to draw the attention of managers to the necessity of reacting to needs and requirements of diverse stakeholder groups. Numerous management principles and techniques are focused on needs and requirements of various groups. The groups mentioned are, and for many years were, customers, now accompanied by employees and suppliers. However, growing complexity of environment company is functioning in, as well as growing access to information, indicate the need of considering more and more diverse group of stakeholders within an organization and outside of it, with their needs and requirements (see Fig. 8).

Expectations of stakeholders are not only focused directly on transactions between parties involved, but also on participation in a debate on social issues (e.g. unemployment, poverty, etc) and proactive consideration of results and effects of activity on society.

Hence, contemporary company according to [58, p. 17] is an organization engaged in mobilizing resources for productive uses in order to create wealth and other benefits (and not intentionally destroy wealth, increase risk, or cause harm) for its multiple constituents, or stakeholders. In that aspect, organizational wealth is defined as "a mean of summarized ability of an organization to create benefits for each and every stakeholder in a long time period" [58, p. 45].

Such increasing care for society is imminent part of QM approach. The new approach to thinking about quality requires taking a look at definition of TQM presented in ISO 8402:1994 standard and at "customer" definition by Crosby. In ISO 8402 [32] standard published in 1994, TQM is defined as "methodology of managing an organization based on cooperation of all its members.

It stresses quality issues and by satisfying customers leads to achieving perspective success of an organization, its employees and society." From TQM definition perspective, it is justified to incorporate social responsibility issues into business strategy. Thus, the direction in which QM strives for, was defined 30 years ago and is still accurate. While its realization by organization depends on the definition of "customer" applied.

In recent years, indications are that the scope of QM has begun to change from "customer satisfaction" into something broader. Specific gravity has moved to providing work conditions, including work culture and quality of relations with environment and social responsibility [48]. The ISO 9001:2005 standard promotes a narrow definition of the customer as an "organization or person that receives a product." Examples include the consumer, client, end-user, retailer, beneficiary and purchaser. According to the standard, a customer can also be internal or external to the organization. Though the standard gives some further explanation for the definition its range is quite narrow. While according to Ishikawa [31] the customer is simply the process that follows ("the next process is your customer"). A broader definition was suggested by J. Juran [39], who defined customer as "anyone who is affected by the product or by the process used to produce the product" where the customer can also be a local community, the environment, and even future generations. This broad definition of "client" is close to the notion of "stakeholder". The term is often used in the sense of those who have a "stake" in the organization. The most famous, but the most general definition of stakeholders was presented by E. Freeman in 1984. According to [22]: "a stakeholder is any person or group that can affect or is affected by the achievement of the organization's objectives". This definition has been the subject of discussion and deliberations in literature [15, 17, 23, 51]. In the model of excellence Malcolm Baldrige National Quality Award (MBNQA) 2011–12, the term "stakeholders" refers to all groups that are or may be affected by the activities of the organization and its success. The EFQM Excellence Model 2010 [19], defines stakeholders as: "a person, group, or organization that has direct or indirect ownership or interest in the organization because it can affect or be affected by the organization or its influence." This approach is close to the definition of Freeman.

Hence, answer to the question whether SD is an issue for QM, is based on the discussion by [5]. They believe that if "quality management is seen as managing quality improvements of goods and services aiming to maximize customer satisfaction subject to meeting the needs and expectations of non-customer stakeholders, then we could choose the boundaries of quality management simply by selecting an appropriate customer definition. If we use a wide definition which could include many different groups of stakeholders, Quality Management should become something similar to Business Management. On the other hand, if we use a narrow definition of customers, Quality Management becomes something much more limited in scope" [5]. Foley [2005, p. 10] argues that if the organization can continue to meet the needs and expectations of the stakeholders, the aim of organizational sustainability will be accomplished. Foley & Zahner [21] have used the definition of the stakeholder to construct an organization sustainability model, which in its consideration of quality as one of the wants and expectations of stakeholders, and as a strategy for guiding the organization to sustainable success, generates a form of QM.

In the next edition of ISO9001, planned for 2015, the stress is put on stakeholders and necessity for sustainable approach to their requirements and expectations via assessment of opportunities and risk emerging from their influence on organizational success. The element binding new and old is the term "stakeholder" and responsibility of an organization for its influence on society [37].

Quality movement moves towards corporate order and elimination of negative influence on environment. It focuses on solving multi-dimensional problems, benefiting from broad definition of "complex quality," referring to all the aspects of social systems, both in public and private sectors. QM works as a main catalyzer of development of corporate social responsibility in an organization. This concept is seen as an approach of running a business in society and environment friendly way, while meeting the most important goal of economic activity, which is increasing wealth of business stockholders. Therefore, it indicates that it is possible to compromise moral principles and rational economic rules, balancing striving for profits and searching for rationale and doing the right thing in terms of respecting interests of wider groups of stakeholders. Hence, QM models (e.g. ISO 9001) can play an important role in facilitating broad social and environmental dimension introduction to corporate strategy, and supporting organization in realization of SD approach.

Thus, it is justified to define the next stage of approach to quality as sustainable QM, which can be management framework for improving quality of corporate development towards SD. However, in the approach, instead of introducing additional set of procedures and processes defining relations between an organization and its stakeholders, theory and practice requires generally various processes, which hitherto were not a part of a normal practice of quality approach. These processes should be capable of dealing with complex problems that are not limited to the subjects traditionally believed to be external. They can embrace any of or all the stakeholders.

5 Conclusions

Over a half-century ago, quality pioneers Edwards Deming and Joseph Juran encouraged organizations to ask better questions about corporate challenges and enabled companies to redesign systems for improvement. They started with a systems approach and then grounded quality in practical analytical tools to foster product, service, and organizational improvements.

Today's SD frameworks encourage businesses to ask better questions about impacts on stakeholders, society, and the environment, and they seek to develop the tools and measures needed to demonstrate improvements. The sustainability of the organization relies on its ability to monitor the external environment for opportunities, changes, trends and risks, and also its ability to learn, change and innovate in response to the results of monitoring. To achieve sustainability, the organization should focus on its results as well as on its processes.

While there has been criticism for many years, still QM philosophy continues to be a central focus for business and mechanism for contributing to better performance. Over the years QM has evolved to become more and more encompassing through the integration of various processes and activities. Sustainability does, however, mean that QM should not be left as an "act of faith" but needs to be managed through taking a strategic perspective, emphasis on measurement and taking action and a continual focus not only on the end customer to meet requirements but also on all those which by their products or processes interact. To rise to the challenges of SD and support companies in realization of this management approach, QM has to be:

- integrative: integrating linked human–environment systems – in order to integrate systems, departments to achieve whole system sustainability,
- inclusive: participatory-based – in order to accommodate multiple perspectives and understand undecidability, and to generate adaptive and innovative capacity,
- adaptive: supporting adaptive modeling of transitions to provide decision-support to adaptive management efforts – in order to be able to adapt to real-world changes as they occur.

I think that there are many ways in which experience in quality managemnt and knowledge in the area can support enterprises in realization of the challenges emerging from SD realization.

However, support seems not to be enough. It is necessary to define activities in the area of QM which need to be carried out and not to exist for managers only as "somtehing obvious and normal" (fourth stage of a lifecycle), but also as the source of inspiration in creating value for stakeholders and support in solving potential and existing problems.

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0012

KNOWLEDGE MANAGEMENT IN THE PROJECT LIFE CYCLE – INITIAL RESEARCH ON POLISH SMEs

Iwona ŁAPUŃKA*, Iwona PISZ**

*Opole University of Technology, Faculty of Production Engineering and Logistics, Opole, Poland
e-mail: i.lapunka@po.opole.pl

**Opole University, Faculty of Economics, Opole, Poland
e-mail: ipisz@uni.opole.pl

Abstract: Contemporary organizations run their activities in an environment, which might be defined as fully uncertain and turbulent. Due to variations that occur in the surrounding environment, an increased attention of management practitioners and theoreticians is paid to new management concepts frequently in an integrated version. The authors express a deep belief that consolidation of approaches to project management and knowledge management constitutes a response to challenge for modern organizations. Research into the issue was based on an attempt to determine significance of the knowledge management issue in a life of projects performed by Polish small and medium-sized enterprises (SMEs). Systemizing of desired knowledge management results in a project, from the point of view of its crucial success factors, is essentially substantiated in providing success of projects performed.

Preliminary research included SMEs in construction engineering industry. The enterprises perform project-driven orders or apply a project approach in economic activities that they execute. Research conducted by the authors so far, implies, that the SME sector is characterized by a particularly low efficiency in project management. Hypothetic assumptions indicate that one of the main reasons of reaching an unsatisfactory level of project proficiency shaped mainly by processes of synchronizing and coordination of project activities, is an insufficient level of development of social, organization and technological systems and methods of capitalization, as well as transmission of useful project management knowledge.

Essential function is performed by a group of selected respondents – 25 enterprises from the group of SMEs, including 5 micro enterprises, 12 small enterprises, and 8 medium-sized enterprises. Analyses performed so far, take into consideration the economic situation of SMEs in Poland.

Keywords: project management, knowledge management, project life cycle, Polish SMEs sector, construction engineering industry.

1 Introduction

In conditions of progressing and global economic crisis, entrepreneurs search for new methods of development and remaining in the market of goods and services, and in marginal cases, the purpose constitutes a struggle for economic survival. It is necessary to introduce variations in the method of business activities running. An increasing uncertainty, resulting from fast variations imposes on the entrepreneurs a necessity to establish and implement new approaches to management in a company [38].

One of the methods includes introduction of solutions based on paradigms of project management into the enterprise practice. Project management techniques may be applied for efficient implementation of enterprise strategy. Project management constitutes an appropriate tool for implementation of quality improvement programs, as it creates a holistic approach to organization variations [43].

Introduction of a project management approach in an enterprise is particularly important for enterprises within the group of small and medium-sized enterprises (SMEs). SMEs sector constitutes a part of economy, which develops very dynamically. Companies that are included in the group of SMEs are able to react to variations in the market fastest – which involves the fact that they may easily adapt to it. Large economic entities are not so flexible. These conditions allow SMEs to act and develop actively in economic niche areas and in low-potential markets. Measures taken by companies from the SME sector contribute therefore to an increase in efficiency of the entire economy efficiency.

Nevertheless, enterprises of this kind are sensitive to variations in the market, they are at risk of turbulences resulting from economic crisis. Change of a business activities running method, distinguishing of tasks in production system that are of routine type and tasks of unique type, the so-called projects, seems to be necessary. Process approach and project approach are significant from the point of view of market position maintenance of a given enterprise [16].

Knowledge management is analyzed usually in the context of permanent organizations, with constant organizations structure; however, there is a theoretical and empirical support for development of the field in the context of temporary organizations, such as project organizations [31]. Knowledge management in temporary organizations becomes an increasingly significant and even a decisive factor in the fight for competitive advantage [4].

Both areas of management science – knowledge management and project management become more and more frequently a subject of scientific research. Not much has been achieved so far in project knowledge management scope that is in a field, which links both the management concepts. Examining knowledge management in projects, it should be remembered that unique project features [40] imply different character of their management [41] and similarly, project knowledge management is somehow different from knowledge management in general.

The aim of the article is to present results of preliminary research conducted at a selected group of micro, SMEs in Opole Province, representing construction engineering industry. Particular attention has been paid to knowledge management, being an extremely important issue in project management. The size of enterprises analyzed is significantly important in the research conducted by its authors; SMEs group, performing a project-driven orders, is particularly at risk of competitive capacity loss, as project management involves application of extensive knowledge, experience, tools and methods and techniques in planning activities in order to reach or to exceed the needs and expectations of employers. This is related to the necessity to combine a lot of parameters, such as, for example: time, cost, requirements and expectations of an ordering party, aims of the project.

A question that therefore appears is: are project teams, which are organized in micro, SMEs for this purpose, able to meet the requirements? Do project managers have proper competencies in the following: knowledge from a given field (I know what), competencies (proceeding knowledge – I know how, and I am able to do it), approach (I know, and I am ready to use my knowledge)? Do the SMEs in Poland use (if so, to what extent) solutions for intelligent organizations and whether the measures improve competitive advantage of the companies (in what areas, if used). Finally, what are the constraints of SMEs sector, in respect of project knowledge management in organization, and what development possibilities for the companies constitute proper solutions for intelligent organizations?

The main purpose of the research is to determine level of project maturity in the Polish SMEs sector, and indicating directions of project management improvement, from the perspective of learning organization features. It is assumed that analyses conducted and conclusions elaborated, shall allow increasing the level of project maturity of the Polish SMEs, by recommending innovative solutions in respect of projects (ventures) execution, and project-driven orders. Context of research directed towards development of learning organization features results from a permanent need to transform enterprises that deal with project management and due to projects transforming from traditional organization into an intelligent one. Processes of generative learning lead to reaching new solutions and facilitate search for new approaches to problems; therefore, they are important also for the development of project maturity of contemporary entities within SMEs sector in Poland.

2 The core of project management

Work of modern enterprises in the world economy under globalization process causes that they start directing their work organization towards execution of complex, unique (and frequently innovative) ventures, that is projects. Projects perform an increasingly important function in management of various types of organizations: enterprises, units of state and self-government administration, non-profit organizations, consortia and their presence is noticed in almost every field of human activity (including professional activity, business activity, science, culture, sport, administration), which certainly raises demand for professional knowledge and management abilities within the scope.

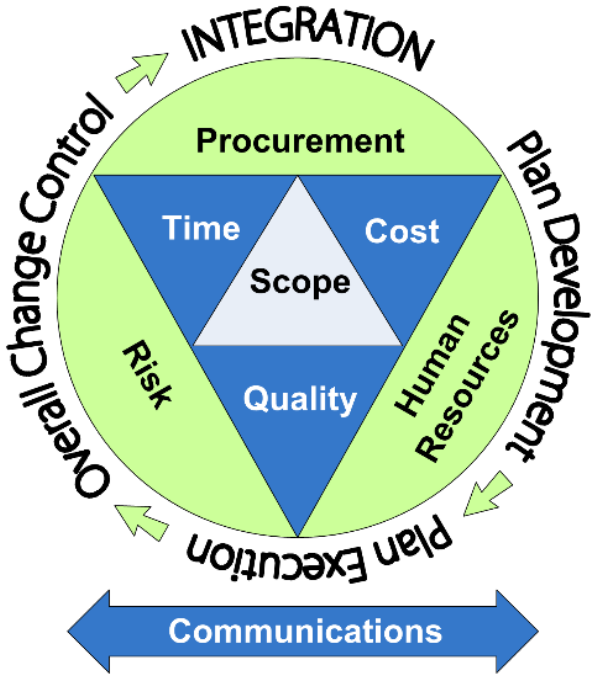

Figure 1. Activities for obtaining project management success (*see [2], [18]*)

Significance of the project issue has been exposed due to the fact of dissemination of the approach to planning within the recent several dozen years, presented by a large group of American organization and management theoreticians, which includes single occasion planning and continuous planning. The definition proposed by the Project Management Institute (PMI) says that "a project is a temporary group activity designed to produce a unique product, service or result".

Project refers to a sequence of unique, complex, and related tasks of various characters with a common aim, to be performed within a specified time, with specified budget, in accordance with requirements established [46]. The purpose of project execution is to reach expected results. In other words, the aim of a project is to reach project parameters at an assumed level, that is, project execution time, project execution cost, and the project performance. Fig. 1 presents basic project parameters, including division of the project into individual stages, which compose into a life cycle: Preliminary stage, intermediate stage – one or a few, final stage with groups of activities under project management (management activities, operation activities, supporting activities).

Project management is based on planning of an activity, organizing, scheduling, monitoring and management of all project aspects, and motivating all its participants with application of respective knowledge, abilities, tools, techniques in order to meet or exceed expected results of a specified venture (project).

Every project has several potential outputs, not all of which are necessarily intentional: 1) a product (or service) delivered for an internal or external customer, and 2) project knowledge related to the product, its production and use:

- technical knowledge concerning the product, its parts and technologies,
- procedural knowledge concerning producing and using of the product and acting in a project,
- organizational knowledge concerning communication and collaboration.

While project organizations have become common, knowledge management of project organizations are still largely underdeveloped. Nevertheless, project organizations require particular systematic and effective knowledge management if they are to avoid knowledge fragmentation and loss of organizational learning.

3 Characteristics of SMEs sector in Poland

Experience of highly developed countries shows that small and medium-sized entrepreneurship performs a tremendous role in economy, influencing economic

growth, better market selection of varied assortment, and helps lower the unemployment rate. SMEs constitute therefore a peculiar stimulus for economy. Their number and potential may be one of the sources of economic growth.

Micro-SMEs constitute a major group of enterprises in the European Union (EU; 99.8%). An identical situation has been noticed in Poland. Entities of SMEs sector include majority of all active companies out of the number of 1.73 million (99.8%). However, in comparison with EU average, the sector of SMEs in Poland is more dominated by micro-enterprises, reaching 96% of the total number of companies (in the EU – 92.3%). The share of small companies in the group of SMEs in Poland (3%) is half smaller from the average of EU – 27 (6.6%), whereas the share of medium-sized enterprises in the structure of SMEs is close to EU average (0,9% – Poland, 1.1% – EU) [30].

The SMEs sector is the main motor of development of national economy. According to Eurostat, the gross national product (GNP) share of SMEs in Poland is at a level close to an average in EU countries. The latest report of the Polish Agency of Entrepreneurship development indicates that the structure of enterprises share in GNP, every second PLN is generated by SMEs (47.6%), whereas the smallest companies generate every third PLN (29.6%). Share of medium-sized entities is three times smaller (10.4%) than the share of micro companies, and the share of small companies is almost four times smaller (7.7%). In 2010, in relation to 2009, the share of medium-sized and large enterprises in GNP increased whereas in micro and small enterprises, it decreased [29], [30].

Average trends indicate that the structure of enterprises in Poland slowly progresses towards a drop of share in general number of micro companies (similarly as in the EU). Share of the remaining companies in turn increases. The rate of the transformations indicates that the highest problem with growth and transformation into small entities is experienced by micro-companies [36].

The sector of SMEs is a source of growth and innovation in all industries, opening job opportunities for citizens of a given country. Seven out of ten new jobs are available in SMEs sector in Poland. Employment in the sector of SMEs in the EU constitutes 67% of employment [34], [29]. SMEs in the world perform a key role in economy shaping. Balanced development of SMEs sector is of essential value for economy and is a necessary condition for economic growth. Companies that are included in the SMEs sector balance negative economic trends, support restructuring of industries, contribute to a high degree to development of global market [1], [5], [10], [19] and [33]. SMEs perform a crucial role in development of innovation to increase competitive capacity, are usually more innovative than large enterprises. This in practice means that innovative activity of the SMEs sector is higher if domination within a given large enterprises is greater. Many enterprises from SMEs sector execute individual client's orders, creating market niches with insignificant turnover and temporary monopolies [24],[44] and [8].

Particular role of SMEs sector results from specific features, which cause that a given enterprise is capable of winning a competitive advantage. One of the most important features of the SMEs sector is their high flexibility and immediate decision making, which is a source of their domination over financially much stronger market opponents. SMEs have got excellent knowledge about local market [6].

The main constraints of SMEs sector companies include lack of sufficient financial resources and resources such as technological resources unlike the large companies, which facilitate a company risk distribution in a portfolio of new products projects and financing of long-term research-development projects [22].

4 Projects management in SMEs sector

Typical problem that appears in enterprises, especially in SMEs, is related with undertaking or not undertaking execution of a new order. Specific type of this kind of problems indicates that they should be solved on regular basis. Most of orders obtained by enterprises constitute individual and single orders that require detailed analysis, elaboration of proper management methods. They are therefore frequently treated as project, pursuant to classical PMI definition.

Project management is based on planning of an activity, organizing, scheduling, monitoring and management of all project aspects, and motivating all its participants with application of respective knowledge, abilities, tools, techniques in order to meet or exceed expected results of a specified venture (project). Project management within last three decades experienced significant development, which may be proved by evolution of project management methodology, by the number of project management certification programs, under-

standing of an impact of project management on general positive result of an organization.

Research on implementation of project management into practice of enterprises, in particular the SMEs becomes particularly important. Research into the status of project management of SMEs sector has been conducted in an insignificant extent.

Owens has conducted research on a selected group of SMEs in Great Britain. The research conducted indicates that most of enterprises questioned, do not implement any standards, techniques, project management tools [25]. Moreover, the enterprises under research do not have any project monitoring or control systems implemented. Organization structures and functions resulting from implementation of projects performed, if available, are not clearly determined.

Tests conducted by Turney's team indicate that SMEs have to individually manage project-driven orders execution and usually it reveals *ad hoc* activities rather than a systematic collection of methods with cohesive project management approach or a collection of principles that refer to methods of a work execution or proceeding leading to a particular purpose. A high cost of selected project management methodology, implementing trainings and certification, constitutes a barrier impossible to be overcome by SMEs [42]. Research results published by Dziekoński, regarding the project management status in SMEs in Poland indicate low competence of SMEs in project management. SMEs sector entrepreneurs do not apply methods or tools available or they do not understand them [8].

Research conducted by Żmigrodzki [48] refer, among others, to problems of project management in SMEs such as: increasing cost of management of projects under execution, variability of demand, delays in projects execution, conflicts in project group, high number of complaints. Further findings of the author refer to basic features characteristic to project management in SMEs. In SMEs sector project management, it is important to approach the issue in view of the whole enterprise, not only from the point of view of a single project. Formal and informal factors, which as a rule constitute a majority, function independently from project management and have an impact on a project, but not reverse.

5 Knowledge as an attribute of contemporary enterprises success

By the end of the 20th century, traditional economy distinguished mainly two factors of manufacturing: labor and capital. Knowledge, productivity, education, and intellectual capital was treated as sufficiently available and as a free resource of environment, which did not have to be included in calculations. To a large extent, the basic nature of the world economy has radically changed within recent several dozen years; its currently dominating features include global competition, turbulent variations, faster information flow and higher scope of communication, technological progress, and a growing complexity of business. Currently, knowledge, obtained with awareness, formed and disseminated by means of various methods aimed at shaping proper behavior of employees and development of information technology supporting the processes constitutes the most important strategic resource of an enterprise. Variations taking place in highly developed counties economy have caused, that terms have been used in description of contemporary economy such as "knowledge based economy", "new economy", "information society".

Turbulent variations (technological, social, political, and economic) of the recent years have directed world economy towards a new direction. Economy based on farming and fertile soil, as main factors of countries wealth, mechanical manufacturing using natural resources in excess, as well as energy consuming technological processes being a key to success in economic race of nations has gone to the past. The world entered an era in which ability to obtain and process information and to produce knowledge are becoming the basis for economic success [39].

There are two basic strategies for managing knowledge [15]. The codification strategy is based on codifying the knowledge and storing it in artefacts and databases where it can be accessed. In the personalization strategy, the knowledge is tied to persons who develop it and is shared by personal interaction. As the main focus in knowledge management concentrates on Information and Communications Technology (ICT) tools and explicit knowledge (codification), face-to-face interaction (personalization), needs to be strengthened.

All knowledge, which the mankind disposes of, doubles currently, on average every 5 years. The time of its multiplication becomes regularly shorter.

At the turn of the 19th and 20th centuries, this time was 50 years [9]. Moreover, an enormous increase in the use of Internet has been recorded within the recent years.

Rich economies, with high level of technological development create information societies, where knowledge management, its quality and rate of flow, constitute basic factors of competitiveness both in the industry and in the services, and the level of development requires application of new techniques, collection, processing, transfer, and use of information.

Digitization of information and permanently growing penetration of all areas of life and labor with new information and communication techniques lead to additional flexibility of structures and jobs. Knowledge, apart from its function as a production factor, is becoming a more and more important subject of production in information society.

Economies based on knowledge and information constitute the most competitive economies in the world, based directly on the production, distribution, and use of knowledge and information [14], [23] and [27]. Highly technological industries perform particular function as knowledge media. Knowledge embodied in new technologies and products within a sector of high technology, and highly qualified resources producing and using the technologies and products decides on innovative character of economy and its modern character and dynamics. As a result, technical-production knowledge included in goods of high level of technological intensity constitutes the main source of growth and competitive advantage [43].

Contemporary scientists do not doubt that the key to success will lie in focusing of effort, on measures and preoccupation with obtaining and keeping in companies persons with unique competencies, lively mind, perfect in action, striving for professional mastery, assuring increase of efficiency mainly by being innovative, thanks to abilities possessed transforming existing resources in new knowledge implemented by means of technology, inventions, products, methods and proceedings [21].

External conditions, such as: ability to use potential opportunities of development, creation of own abilities, predisposition to self-development, and self-education of society become the basis for significant endogenous factors for development (technical progress, development of human capital) of economy. Lack of such conditions or their relative instability increase disproportions in development, leading to a relative peripheralization of some economies in relation to other ones in the aspect of competitive advantage [11].

Such situation is a cause of higher demand for a focus of an enterprise on knowledge management processes as a basic concept of managing a modern organization. It integrates processes regarding areas of creativity, innovativeness, contacts with customer, application of the best practices, learning and development of abilities. It also includes aspects of building a culture based on knowledge. Hence, knowledge management is by its nature complex, covering all areas and aspects of organization functioning [37].

Knowledge in activities of an organization, including projects execution, has been for years within the scope of interest of researchers, who confirmed its key significance for construction of permanent competitive advantage of companies and enterprises. In project management, the topic takes a new character as it becomes transferred into a field of dynamic, time-limited, temporary, and team-performed ventures. No extensive research has been conducted in Poland within this field and literature presents the issue rather from theoretical and model perspective than empirical one.

Research conducted in 2011 by Paweł Wyrozębski [45] on a group of over 300 specialists on project management referred to frequency of application of 10 knowledge management practices defined within project activity of Polish organizations. The research clearly indicates that higher the experience and professional achievements of a respondent, the more frequently he/she applied knowledge management and organization good practices in their work. This means, that higher management staff find an important function and task in company functioning and in execution of tasks to be performed. A lot remains to be improved within the aspects. A wrong practice is to leave the field without influence, which constitutes a risk of serious losses for companies. They appear mainly when a person responsible for performance of certain tasks in a project leaves the company, taking his/her knowledge and experience away. Test results obtained indicate that project management is a field that becomes in particular way a beneficiary of knowledge management, creating a new quality, and enriching achievements of both fields [45].

6 Project knowledge management in SMEs – characteristics of initial research

Research into knowledge management in a life cycle of projects executed by construction engineering companies within the SMEs sector, constitutes a continuation of research performed since 2012 in the Department of Project Management at the Opole University of Technology [26], [20]. The questionnaire research was designed to obtain an answer to the following questions: how entrepreneurs from Opole Province manage projects, what obstacles they find in reaching aims, what is the impact of project engagement on competitiveness of enterprises on market. Twenty five enterprises from the SMEs sector took part in the research, including five micro-companies, twelve small companies, and eight medium companies.

The questionnaire research performed by the authors indicates that most of the enterprises questioned (about 80%) do not have an overall approach to project management. Projects undertaken by entrepreneurs are characterized by relatively short execution times, in case of micro-companies (up to 3 months). Projects execution periods, in case of a small and medium-sized enterprise are significantly longer, they are on average 3-6 or 6-9 months long.

As one of the significant areas of knowledge in project management includes human potential use, the authors decided in 2013 to continue the research with the same group of respondents with regard to building of project teams, competencies of their members, function of intellectual capital, and level of knowledge management in projects life cycle.

An important condition, favorable for development and obtaining competitive advantage by knowledge management, is a method of use of human potential. Traditional recruitment of employees becomes obtaining intellectual capital. The most important factor is not the size of an enterprise, but its culture. Employees constitute the most important assets of a company and a process of education has been transformed into education of increase of entrepreneurship [32].

Focus on human capital is conditioned by many variables. From the point of view of the whole economy, investment into human capital depends on globalization processes, transformation, level of economy competitiveness, and its entities that determine in a significant way appreciation of human factor function in economic processes. Company running its activities on the basis of knowledge, should use not only existing knowledge but also aim at its purposeful improvement and complementing [13].

Due to specifics of the research, techniques of uncontrolled observation and free interview have been applied. This allowed better presentation of construction projects execution process, identification of functions of a manager from the point of view of key success factors, and indicating shortcomings in selection of members of project teams. Moreover, it facilitated watching the level of shaping social, organization and technological systems and methods of capitalizing, handing over of useful knowledge regarding project management within the SMEs group under the research.

Projects management is a field where the so-called project management competences models or project managers competencies models can be noticed to become very popular. Organizations responsible for their elaboration and development include usually professional associations such as: Project Management Association (IPMA Competency Baseline), Project Management Institute (Project Manager Competency Development Framework), Engineering Construction Industry Training Board (National Occupational Standards for Project Management), Australian Institute for Project Management (Professional Competency Standards for Project Management).

From the point of view of world standards, the models established so far indicate scope of complex and detailed guidelines, which define elements and levels of project competencies needed and required from organizations and from employees who perform specific roles and functions in specific positions.

Project management practice in SMEs is, however, totally different from standards established. Research conducted so far by the authors indicates that modern SMEs usually do not undertake projects based on analysis of competencies such as: knowledge, abilities, approaches, and behavior of employees obtaining outstanding results. Not many project managers use proper tools and methods of projects management. Level of project maturity of individual companies is very different, and project awareness of construction team members (project teams) is also varied, but is definitely on a low level.

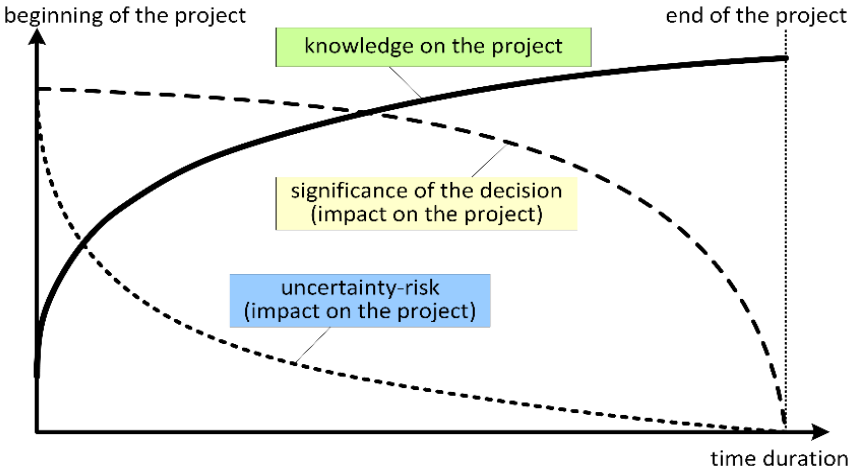

Figure 2. Significance of decision compared to knowledge on project (*see [47]*)

Transformation of project initiative into material results, creating a value for organization within enterprises under research from the construction branch in the SMEs sector is chaotic, in principle, significantly tangential from project-based programs assumed at the beginning, without implemented methods of project management methodologies, and it usually reminds rather *ad hoc* activities than a systematic collection of methods forming a cohesive approach to project management.

Lack of proper competencies (knowledge, abilities, and attitudes) of project team members, including project managers of projects performed by SMEs, cause significant consequences in reaching (or not) of the project purpose, within a specific time, at planned cost and of required quality.

Exceeding a directive deadline for project execution appears in each of the enterprises under research. Financial penalties imposed by the contractors constitute a consequence of exceeding the directive deadline in medium-sized enterprise. Micro and small enterprises usually negotiate extension of execution time with contractors, which lowers their reliability viewed by customers, loss of next orders of a given customer. In relation to cost management, the research indicates mainly weak points of practice in project approach of the enterprises under research. Most of enterprises under research do not apply sufficient project calculation, which results measurably in exceeding the planned budget level.

The entrepreneurs asked indicated that at estimating of time and cost of individual tasks in the project, they do not use knowledge or experience of employees working at previous projects (almost 80%). They do not use any formal methods, time estimation tools, or project execution cost calculation (67% of micro and small enterprises).

Main conclusion of the observations and analyses above is the fact that, in particular, the SMEs need competent project managers, who will be able to manage efficiently, and manage execution: introduce organization variations and new technologies, implement strategic development projects, hand over construction objects on time, pursuant to budget and quality requirements.

Moreover, specifics of contemporary entities of the SMEs sector should be associated with learning organization, organization oriented into permanent obtaining, transforming, and popularizing of knowledge on markets, products, technologies, and processes. Interference of events, phenomena, and processes inside and outside organizations gradually displaces process individuality in business activity. Economy transmigration towards chaos, unpredictability, and a phenomenon of uncontrolled dynamics causes also that SMEs apply institutional mechanisms of learning and their introduction as a permanent element of project organization culture.

7 Knowledge management in the project life cycle

Project management is a management field that deals with application of knowledge available, abilities, tools, and techniques in order to meet demand and expectations of projects clients.

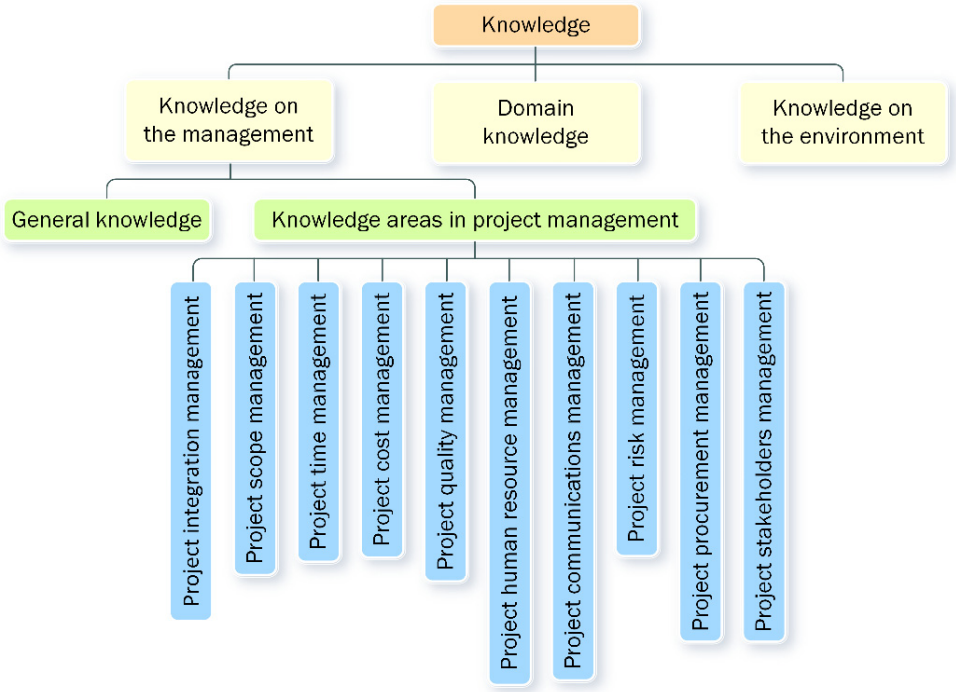

Figure 3. Kinds of knowledge required for projects
(*see [12], [2]]*)

Pursuant to the definition, project knowledge may be considered a useful information resource facilitating projects execution pursuant to time, cost, and results quality aims.

Projects nature involves particular dependency, which is not directly described by project management standards, but is accentuated in the background. Significance of decisions and its impact on project is, in principle, inversely proportional to the project knowledge possessed, both at the beginning and at the end of a project (see Fig. 2).

Existence of the relationship influences the whole structure of methods and processes of project management starting from baseline elaboration, through progressive planning, staging, and risk management to post-project reports [47].

Projects are characterized by a high level of uncertainty at the beginning of their execution. It results from one of the project definition features – providing of a novelty, hence with significant amount of unawareness burden. A project is executed progressively by means of subsequent approximations. If there are so many unknown data, any initial estimates and assumptions may turn out untrue, that is, a task may take not one day or a week, a product may cost twice as much, new technology will be much more efficient than assumed and a new supplier turn out unreliable.

Knowledge at the end of a project in turn, when everything that was incorrect and correct had already happened, is a complete knowledge. Actual task times are known, cost of the project is known, it is known whether the customer is satisfied, weak and strong points of project teams, etc. are known. Throughout project life cycle, knowledge about it grows from almost zero to agreed level of 100%. At the beginning of a project, managers are at the same time forced to make the most important decisions. This involves existence of a serious paradox – the most important and the greatest number of decisions have to be made at the moment of the highest risk.

Knowledge necessary in a project includes various areas (see Fig. 3 and [47]):

- knowledge on competencies and attitudes of project team,
- knowledge about approach and aims of project parties,
- knowledge about technology, chances, and difficulties related thereto,
- knowledge about business situation of customer or a supplier,

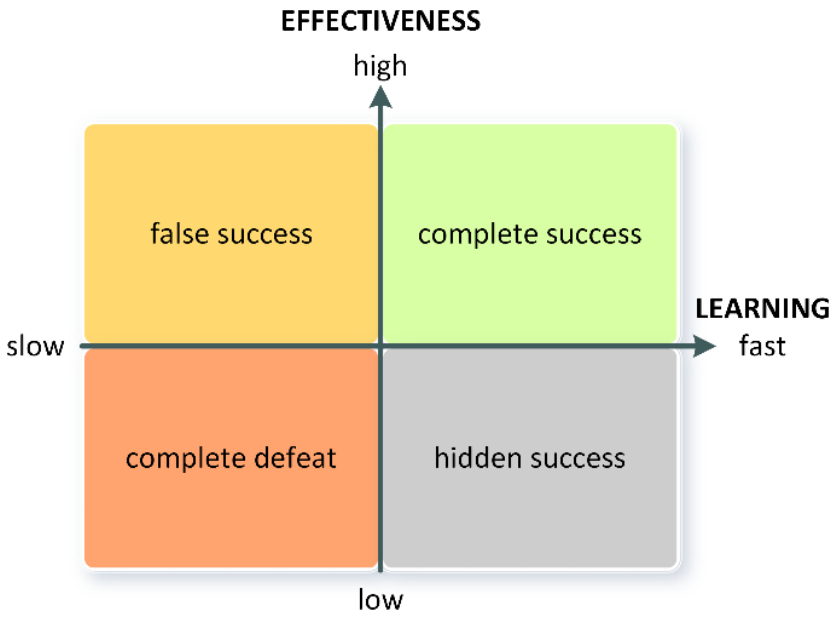

Figure 4. Project success – extended overview
(*see [3]*)

- knowledge about other projects under execution in an organization,
- knowledge about business and production processes and office works related thereto,
- knowledge about natural or legal environment in which the project is performed.

Damm and Schindler [7] distinguish in turn, knowledge about projects, knowledge in projects, and knowledge from projects. It is related with the process of learning during execution of each project. Knowledge and experience gained in this way may be treated as accumulative intellectual capital of an organization and as one of important project success factors (see Fig. 4).

Project organizations have tremendous possibilities of learning at projects [35], they are therefore considered intensely learning organizations. Frequently, however, measures taken by them do not confirm the assumptions. The end of a project is usually associated with exhaustion of learning possibility, and the effects of learning under one project are not transferred further to others and become forgotten. For a project-type organization, it involves high cost of lost possibilities to improve project management techniques and methods. Organizations may and should learn from projects, by use of knowledge resources collected and by creating opportunities for concluding from measures taken and their effects on employees [17]. A condition for use and application of knowledge is to collect it and make it available to all employees.

Fig. 5 presents a situation when project team may use organization knowledge (blue line) collected also at previous projects. PMBOK guide characterizes it in general: Organizational Process Assets, that is an intellectual capital of a company. Difference between traditional situation and possibility to use additional know-how constitutes just a start-up from a better position for a project team, that is, at a higher level of knowledge about a future project. For example, if a database of suppliers is available, it is known who should be avoided during a tender; if a database of task times is available, it is possible to evaluate efficiency of people and reliability of their forecasts [47].

One of the management aims is to expedite project knowledge increase so as to reduce area of uncertainty as much as possible or to postpone risk decisions in time. The learning curve should therefore be as convex to the top as possible, which is presented in Fig. 5 by a green line.

During a project, it is possible to learn faster or slower. It is, for example, possible to wait for weeks for a result of a large package of works executed through outsourcing, and notice at the end that a contractor was incompetent. Work could also be divided into small packages, a regular inspection at a contractor's could be introduced and a reaction thereto at the very beginning applied, when problems are noticed.

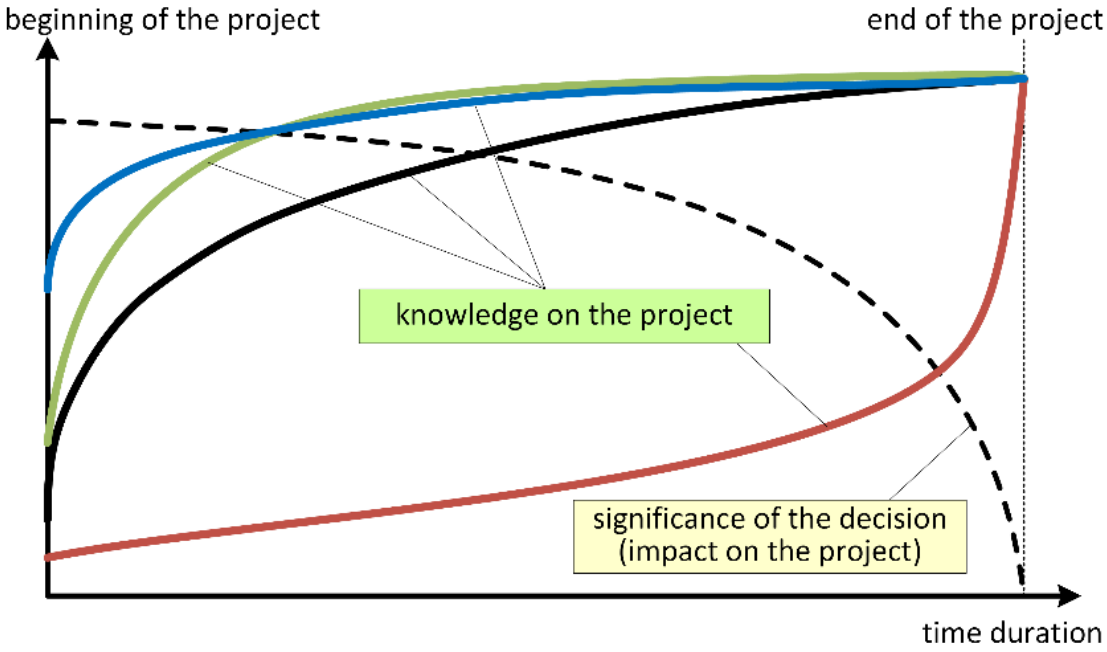

Figure 5. Significance of decisions compared to project knowledge supported with knowledge about organization (*see [47]*)

The main problem is to run projects in chaotic manner, when project team has not agreed complex requirements, concepts, or scope, which causes conflicts and problems; project knowledge will be collected extremely slowly (red line in Fig. 5) [47]. It is better to run incorrectly a well-planned project than to execute well an incorrectly planned project (a paradox resulting from Murphy's laws).

One of the main challenges of project management is the minor and tangled accumulation of knowledge. The content and quality of the knowledge created vary, as well as the ability of organizations to utilize it. In this study, knowledge management in a project is considered to consist of four groups of activities: (1) knowledge creation, for example, collection, combination, and refinement, (2) knowledge administration, for example, storage, organization, and retrieval, (3) knowledge dissemination within and outside the project, and (4) knowledge utilization and productization, for example, integration into products and decisions, and application in other projects.

8 Quality research results – exploration stage

A literature analysis of issues and quality research has been conducted under the research on project organizations intelligence within SMEs sector (exploratory stage). Quantity research is in progress (diagnostic stage). The crucial aim of quality research was an attempt to explain and understand phenomena related to project organization functioning in the context of generative learning processes, including causes and rules that govern them. Exploration research was conducted in September – November 2013. Twenty-five extended individual interviews in construction industry enterprises of SMEs in Opole Province have been carried out under quality research. Moreover, four main areas of good practices of SMEs as intelligent organizations managing project-driven orders were identified and elaborated within the quality research. Diagnostic stage will constitute crucial part of the research. It will include quality research, which will be performed from January to June 2014. It will be performed by means of direct questionnaire interviews using a paper questionnaire (PAPI). Quantity research shall be performed on a sample of about 100 micro, small, and medium enterprises that perform project-driven orders.

For the needs of the research, a definition of intelligent organization was adopted, which implies that a project organization modifies its behaviors, according to knowledge obtained and variations in external environment. Due to the fact that it involves specialized processes related to creating, shaping, and transfer of project knowledge, learning by its all members, in particular, by project teams, becomes easier.

It was, moreover, assumed that a project-intelligent organization is an organization that performs the following activities: (1) systematic problem solving in projects, (2) experimenting (regular research, testing of new knowledge, search for new methods of problem solving), (3) learning on the basis of previously gained experience during execution of projects, (4) learning from others (including benchmarking), (5) capitalization of project knowledge, (6) transfer of knowledge by organization in a fast and efficient manner.

The purpose of information analysis obtained in individual interviews with management staff of the SMEs sector entities that execute project-driven orders consisted in obtaining identification and description of: (1) external and internal factors, which contribute to learning and elements of project knowledge management strategy in intelligent enterprises of SMEs sector, in construction engineering industry, (2) methods of human resources management and a required competencies profile of a manager/member of project team in intelligent enterprises of SMEs sector, (3) competitiveness factors, constraints, and development requirements of intelligent entities within SMEs sector, which execute project-driven orders.

The research conducted implies that characteristics of projects which differentiate them from routine activities of enterprises cause, that project management is definitely more difficult than knowledge management in traditional organizations (in particular, for SMEs), but it also may bring potentially higher advantages. Two basic features of projects, identified mainly with drawbacks in project knowledge management, include project time limiting and its unique character. Projects' uniqueness results not only from unique aims of projects but also from other causes. Projects constitute activities being directed towards a short-term cooperation of interdisciplinary teams formed by internal and external experts for an organization, and they constitute unique groups of employees. Hence, specifying three main project parameters – time, cost, and resources, constitutes a serious constraint for project knowledge management.

Due to time limiting, the SMEs under research indicated lack of time to collect valuable project knowledge. Additionally, because of human nature features, project team members are reluctant to consider defeats and incorrect project execution decisions, which might frequently constitute a valuable source of knowledge. Moreover, frequently, knowledge collected during project execution disappears, especially in SMEs, when a project team, that is organization structure employed in project purpose execution becomes disintegrated, and individual persons come back to work in organization departments. Due to lack of further project meetings, teams existing continually in traditional organizations become disintegrated. Even project documentation (especially in SMEs), which may constitute a source of project knowledge, is located in a rather unknown location and is not available for those who would like to use knowledge and experience of others.

Worth noting is the fact that an increase in project activity of organizations results in various effects. It involves not only decentralisation of organization structure but also segmentation of organization knowledge. SMEs sector project organizations usually do not have structures that collect and store knowledge in traditional organizations. In projects, it is, however, important that knowledge and skills obtained during execution are collected and archived in an organization in a manner, which is available for all subsequent members of projects execution. It implies that SMEs working on project-driven basis or by project-driven orders that do not collect project knowledge, suffer greatest losses, due to tremendous potential and opportunities in obtaining project knowledge and its use, its application and implementing in subsequent projects.

Project organizations, including SMEs, frequently execute several projects/project-driven orders simultaneously, which causes that knowledge management is even more difficult but potentially more advantageous. Traditional project management focuses on activities such as planning, organizing, management, and control of resources directed towards execution of the project aim within time scheduled and within a specified budget.

This indicates that in traditional project management, the work of a project team must be efficient and effective, and to guarantee its execution in this manner, it is necessary to introduce knowledge management processes within an organization, which are rarely executed in project-type organizations. SMEs make expensive investments into improvement of project works under execution, but hardly ever invest in projects evaluation, which obstructs learning from them. The following problems related to analysis after a project have been identified (lesson learned): people do not remember what happened in initial stages of a project, they go to

other projects and it is difficult to collect them for a review, there is no time or money in a project for reviews, company management's main interest is focused on effects of a project not on knowledge collection.

Its conclusion is that in the best case, project knowledge constitutes an individual knowledge resource of individual organization members, to be used by them in the future.

Luckily, an increase in project manager's awareness regarding necessity to manage project knowledge caused intensification of and an attempt to systematize organization measures within this scope. Interviews frequently focus on indicating the necessity to increase project organization intellectual capital by: improvement of knowledge of individual employees (trainings, courses, etc.), intensifying cooperation within project teams (inside, and between them), increase of knowledge transfer between employees (communication). All initiatives undertaken are worth noting, but frequently, activities only, their quality and effects are far from an ideal, which causes why SMEs sector organizations do not use the potential offered by organization and project knowledge.

9 Summary

To summarize quality research results obtained from entities of SMEs sector, it should be emphasized that there is certainly a low level of project-driven orders execution solutions implementing, proper for intelligent organizations. It is compliant with the hypothesis assumed, that the key problem in projects execution is an improper management of project knowledge, revealed by low efficiency of its use, and mainly a weak ability of organizations to accumulate project knowledge and loss of organization memory.

The phenomena result in an insignificant efficiency of projects, low quality of results, dissatisfaction of project employers, and ineffective management of resources designed for their execution. Weak level of organizations learning and use of project experience leads to an unwillingness towards execution of innovative projects, and as a result, to a loss of chances – not only from the point of view of business activity but also of the social and macroeconomic ones.

To improve the situation the following recommendations were indicated, in individual interviews with management members of SMEs sector: (1) documentation of the knowledge obtained in projects, at best on a regular basis, (2) generating employment and cooperation conditions that support knowledge exchange, (3) maintaining of organization knowledge map, (4) search for knowledge existing within an organization, before "wheel starts being invented" again. The instructions listed, directly influence project management, which in its essence is related to knowledge processing.

Project team members, who have specialist knowledge – work together under a project, to supply new products and services on time, according to budget and specified quality criteria. From this point of view, it is important for a project manager to manage knowledge of its own team and interested parties – he/she should integrate it as much as possible to facilitate execution of a project in a successful manner. Project team members, also manage their knowledge – individually and in a team – using the possessed knowledge and attaining new knowledge, handing it over to others, and creating together new knowledge within an organization. Application of knowledge management methods in projects execution is therefore significantly substantiated in order to guarantee success in ventures executed.

Knowledge-based economy opens new challenge for enterprises, in efficient and effective development of organization-learning processes. The research conducted indicates, that the level of progress of SMEs sector entities in adjustment to current economic challenges is still quite low. This is indicated by quality research results, and preliminary estimates for quality research assume confirmation of the hypothesis concerning the assumed index at a level of about 12% – only less than every eighth enterprise executing project-driven orders may be specified as an entity with features of an intelligent organization.

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DE GRUYTER OPEN
Foundations of Management, Vol. 6, No. 2 (2014), ISSN 2080-7279
DOI: 10.1515/fman-2015-0013

METHODS AND TECHNOLOGIES SUPPORTING INFORMATION AND KNOWLEDGE MANAGEMENT ON THE EXAMPLE OF THE POLICE

Agnieszka SZCZYGIELSKA

Institute of Management, Management and Command Faculty, Warsaw, Poland
e-mail: a.szczygielska@aon.edu.pl

Abstract: This work refers to one of the hierarchical organizations, which is the police. The example of the Municipal Crowd Management (*Stołeczne Stanowisko Kierowania; SSK*) has been chosen as the basis for a detailed analysis presented in this article. The Department, as the place where the work of many individuals, departments and services is integrated, must demonstrate a high level of knowledge, competence, and coordination activities. The innovative technologies appear to be the unquestionable support. They should primarily serve the needs of managing knowledge on the efficient actions in relation to the socio–market requirements. In case of this organization, these solutions play a vital part in the creation of intelligent organization to support its activities focused on delivering effective public services and thus contributing to build the knowledge economy in Poland. An attempt to present the discussed issues has been taken in this study.

Keywords: hierarchical organizations, knowledge management, high-technology, the police, police management.

1 Introduction

Modern management imposes new requirements on the executives and public authorities. They often refer to deep foundations and basic philosophy of their actions, but often the base of what is already fixed turns out to be the most difficult to change. Conditions of these requirements can be summarized as the following demands:

- prevention of the emergence of problems instead of solving them (understood as a diagnosis rather than treatment),
- supporting the citizens of the state in solving problems (the desire to help and give advice),
- creating opportunities and the opportunity for success,
- openness to new technologies, ideas, and management methods.

In a knowledge-based economy where speed of response is important, modernity of applied solutions and accuracy of decisions, an integral and natural part of daily management becomes innovation.

It should be remembered that there is a very strong relationship and mutual influence between innovation and knowledge. Innovation is a kind of transformed knowledge, modified, revised, useful, sometimes formally approved and finally implemented in practice.

Innovation undoubtedly involves expanding the range of knowledge in the organization, especially if the source of this knowledge is external and not internal. Such situation requires more organizational activity associated with learning and absorbing new quality of knowledge or even updating and verifying the already acquired knowledge. A company whose innovation has an impact on the actual real activities, depends primarily on the people, the desire to use their intellectual potential, creativity, commitment to the objectives of the institution, and the flexibility to change.

The main objective of this paper is to highlight the role of information and knowledge management in public organizations in Poland, with particular emphasis on hierarchical organizations, at this point the police. The intention of the author is an attempt to approximate knowledge management issues by quoting practical activities carried out in the public sector. The intention is also to show the selected elements of this concept in the Municipal Crowd Management and their impact on improving the effectiveness and efficiency of these services.

2 The essence of knowledge management in public organizations in the knowledge economy

Currently, in any organization, and especially in those that have adopted the goal of serving the society, providing a sense of security and taking care of the everyday life, we came "(...) to deal with a very difficult opponent: ourselves. Who is able in time to see that solutions developed so recently and so hard again require a change? Who voluntarily chooses to put question mark at its greatest successes and announce the need to seek new answers to the challenges of the future? Who would be happy to take up the demolition work of their own hands?" [5, p. 151].

Rapid development of modern technology and the growing needs of society seems to be the only reasonable option, and not just for market, manufacturing, or service companies, but also for the public institutions. The ultimate goal of these actions is to create a modern state corresponding to the requirements of the knowledge-based economy and the persistent further changes in the world as well as to build a coherent network of public services to provide an efficient safe state for the benefit and satisfaction of its citizens. Building on these assumptions, it is impossible to accomplish this apart from the issue of raising awareness about the role of information and knowledge in all forms of state functioning and the ability to manage these resources. This, in turn, is linked inextricably with the attitude of pro-innovative, open technology and the use of all available upgrades in the performance of work. It is clearly emphasized by D. Snowden of IBM saying that "knowledge management is to assist decision-making processes and creating a context for innovation; nothing else matters." [9, p. 8]

The implementation of these conditions and demands is to serve the concept of an intelligent organization, where there are often objections on the possibility of its implementation in public organizations. We must bear in mind that none of the contemporary concepts will be possible to implement in its pure form in every organization, as each one has a different specificity and culture activities. It is important for each of the novel concept of effective management to make an attempt on the introduction of the key distinguishing marks of a concept to serve and support implementation of its goals in the consolidated form. "Intelligent organization is primarily a community of professionals well understand each other, partners in creative action, capable of continuous transformation of products, processes, structures and themselves in an effort to meet the requirements of the market and the challenges formulated by society." [12, p. 19] In the intelligent organization, we can discern different levels and types of knowledge; the executive level can recognize, which knowledge resources form the so-called *tacit knowledge* (also, *tacit knowing*) and which form *explicit knowledge*, defined by others as an expressible or available. Managerial level is also able to determine in relation to specific individuals, which knowledge is in the form of a personalized, explicit, and/or tacit, and which is in the form of codified knowledge. A good manager and leader is able to locate it, follow, at least some of it to personalize, translate into the language of signs, and make available to a wider audience stuff.

During the identification of individual intellectual resources and the dependencies remaining between them and establishing the blockages and breakpoints, an effective manager of a knowledge-based organization and manifesting the characteristics of an intelligent organization, can influence through all sorts of activities to increase the effective functioning of the group or the entire organization. The leader takes on the activity in the area of knowledge management and development of intangible assets. Many of these activities can be defined as "an effective learning process associated with the exploration, exploitation, and dissemination of knowledge (explicit and tacit), using appropriate technologies and cultural environment, which aims to increase the intellectual capital and the efficiency of the organization." [7, pp. 27-28].

In an organization such as the police, it is difficult to implement the requirements of a specific and strict knowledge management model and the precision to act in accordance with its guidelines as it has previously been mentioned in case of the implementation of the intelligent organization model. It should be remembered that knowledge management can be seen in the daily activities as well as through conscious realization of the fundamental processes supporting various activities. This applies to the activities shown in the Fig. 1 [15].

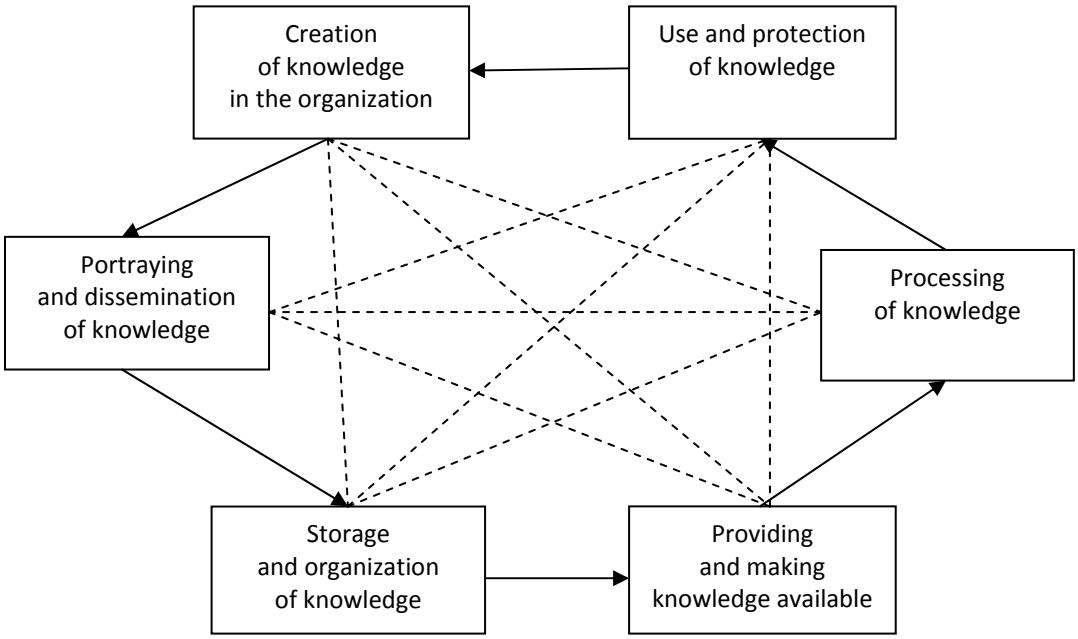

Figure 1. Fundamental processes of knowledge management
(*source [15])*

It is also important, especially in the case of the police, to adapt to what is imposed by the present. This reality is well illustrated by a quotation, made in the U.S., which should be introduced in the way of thinking of Polish units: "To win the war against terrorism, we have to think like a street gang, move like a soccer team, and communicate like Wal-Mart." [see also: 21] Distributed by a legitimate business philosophy, it reminds us that to be effective you must draw inspiration and benchmarking against best practices and constantly update knowledge. Prior to the establishment of these imperfections and the need for continuous improvement, it should be repeated like a mantra in daily functioning and applied to practice. The introduced culture of learning and creativity imbued with courage to predict tomorrow proves to be very valuable.

The organizational culture in the police is a bit different from the traditional institutions that often have very differing cultures, even in hierarchical institutions, and despite strong legislation, the implementation of fundamental values at the level of workers' mentality is really possible. It seems that in the context of knowledge management, they should refer to continuous learning and personal mastery [See for example: 20], obtaining information and knowledge from all available sources, importance of teamwork, the need of the most profound knowing of the other side (that is, at this point, people who present a very real threat to society and the state, to be able to anticipate their possible decisions and movements, and in the absence of such opportunities to have wide experience facilities) and the development of systems thinking skills. The value of innovative and conscious use of all availed facilities, persistent search for many more opportunities for improvement, and ultimately the awareness that at any moment you can achieve something even more perfect than the status quo, must be also recognized.

The police should have undeniably the most modern technological facilities for gaining information to support learning and the creation of new knowledge. Resources management as well as the creation of the whole intellectual capital should be considered here as complementary, interdependent, and overlapping processes, because intellectual capital is derived and is the result of skillful use of knowledge in practice [23].

The widespread use of modern information technology is noted not only in highly developed countries. *Sanjay Sahay, Inspector-General of Police, Eastern Division (Davangere) in India, said* police personnel should concentrate on improving their knowledge of technology[1], as cyber crimes are increasing. He added that the

[1] It is worth mentioning that the Higher Police School in Szczytno has already held three conferences on Modern Technologies in Security and Public Order (NTSPO). They were devoted exclusively to the role of modern technology in security

awareness among police personnel about the latest technologies will play a key role in preventing crimes. It is worth noting that in such a small town and country where technological development is not considered as being at the highest world level, the importance of the role of these technologies and knowledge resources in the development of secure state is recognized and valued [24].

A great emphasis placed on the need for education and continuous improvement of officers in the units of the Polish Police Service may arise partly from a noticeable tremendous progress and rapid access to information and the use of it for criminal purposes by various individuals and groups. In recent months, for example, the need for training in the field of combating economic crime (its range is covered by more than 100 legal acts) in connection with uninterrupted socio–economic changes and cunning ability to find loopholes by persons involved in numerous business processes and pseudo-business has been raised. According to J. Zarzycki[2], the training in the prevention of economic crime is "(...) necessary not only for new applicants but also for *the old pros* perfecting their skills. (...) The officers involved in the fight against economic crime, apart from specialized knowledge, should be primarily open to every form of general knowledge." [26, pp.11].

Keeping abreast with current technological changes should be very essential for police executives because today's managers must not only be fully aware of the development of modern technology but also have knowledge about what this technology might perform in their institutions, faculties, individuals or groups. The managers should also have the ability to acquire technology through a variety of funding sources. It is obvious that employees prefer having outstanding and innovative equipment that by the very fact of its possible use at work can affect raising their morale and motivate to work more efficiently and be more involved [see also: 22]. It also increases their sense of security and professional skills.

and public order, training programs and professional development; an attempt was made to introduce these educational concepts at the managerial level and research has been directed at the implementation of these issues.

[2] Junior Insp. Jaroslaw Zarzycki serves as head of the Department of Crime Combating Economic Crime Bureau of the Police Headquarters.

It should also be emphasized that, in spite of available modern technologies and additionally employed experienced employees, the strict regulations prevent the pragmatics of modern systems from implementing to practice, which leads to ineffective uses of their capabilities. Thus, there is a situation when experienced people and IT facilities are availed but are followed by legislative blockade. For example, the DNA laboratory in the Biology Department of Central Forensic Laboratory of the Police equipped with innovative devices on a global level uses the services of eminent specialists in this field but, unfortunately, the regulations greatly restrict the access to the equipment. This refers to the collection and storage of personal data by the police. Such a policy significantly reduced the chance of obtaining material bases and made (described further below) Automated Fingerprint Identification System (AFIS) database full of loopholes and, in fact, more useless tool than expected [13, pp.13]. This situation is regrettably extremely frustrating with its overtones of helplessness and lack of influence on the change in the near future.

Searching for effective management solutions and attempts to implement interesting applications cannot be forgotten that in the first place, it is necessary to change the role of knowledge awareness, speed of obtaining information, and the use of all technological facilities for the benefit of society. This does not apply only to officers, employees of uniformed services but also to individuals cooperating with said services, legal and regulatory institutions. It is intended that the final should be sought, if the law actually protects and is not a real barrier for citizens in the process of truth creating another stopping points, building artificial walls to shield misty suspected social interests.

3 The Crowd Control Department of the Metropolitan Police Headquarters Knowledge Management

The basis of presented issues and practical aspects of the concept of knowledge management in the Municipal Crowd Management Department of the Metropolitan Police Headquarters is open. It was complemented by the author of selected information technological solutions during daily work and observation of work in the section on duty. Collecting information is supplementary in-depth by telephone calls.

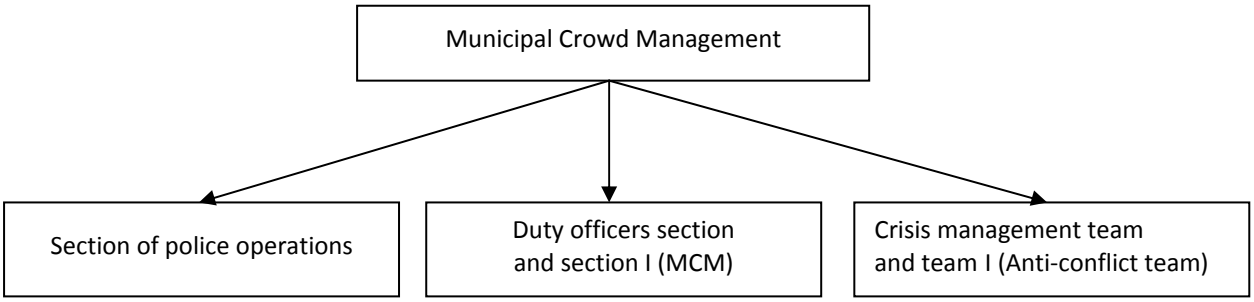

Figure 2. Municipal Crowd Management and its sections
(*source: own work*)

The interview was conducted with the person working actively in the SSK. The research was qualitative in nature, referring in tone, and discussed aspects of the pillars of the concept of knowledge management.

Personal observations made by the author in the Municipal Crowd Management allowed largely to confirm the information obtained during the interview and perceive further opportunities for growth, expansion, and list numerous sectors where additional assistance would be needed in order to further improve the performance of their tasks and thereby increase the efficiency of work for the society.

In order to justify further comments and proposals made by the author, it should be borne in mind that the Municipal Crowd Management is a department of Metropolitan Police Service running its tasks through specific sections and teams as shown in Fig. 2.

Looking at the work of this department, it may be noted that it combines and coordinates the role and responsibility of multiple units while working closely with other public services, such as fire department, military, and health care. The degree of procedural order work must therefore be at the highest level, which means that the Municipal Crowd Management is an even more complex task to be performed. Technological solutions applied in this unit primarily refer to the information and coordination technologies in supporting management of information and knowledge resources as well as techniques to organize a knowledge-base in such a way as to ensure the safety of citizens, for example, in the case of mass events, state celebrations, or public gatherings. For this reason, all of these activities and solutions are of particular importance for described unit operating in the capital. Municipal Crowd Management through its actions somehow would be an example how to integrate and connect with other departments and in addition, supervises and divides the tasks. Just as the activities of the appointed head of the organization set some patterns and models of behavior, the Municipal Crowd Management department is regarded by others as a point of relevance in terms of different actions and inspiration for further achievements.

With respect to individual knowledge management processes [18], it seems necessary to organize a set of internal seminars in the near future offering trainings in different areas. Within the following categories, a seminar program should be continuously developed on issues relevant to the specialization of individuals or groups, highlighting the valuable role of mentoring and inspiring coaching. Training sessions should be conducted by experienced staff or invited experts. This would facilitate the acquisition and better flow of knowledge as well as contribute towards drastic reduction of bureaucracy and the degree of stiffness in mechanistic organizational structure of the Police, which is recognized by the staff as one of the essential elements blocking their growth and the undertaken actions less efficient [11]. The implementation of knowledge transfer session would be also valuable that would involve structured meetings devoted to the exchange of knowledge, for example, between individuals from different organizational units. Therefore, extremely valuable is people talent management, providing training and concern about interpersonal relationships in the workplace, and encouraging the sharing of their knowledge. Undoubtedly, cooperation in a virtual *SPACE* in disseminating knowledge could become more convenient, for example, computer programs to help those involved in the project to remotely interact and ultimately achieve the objectives of the team.

The base-knowledge and data warehouses seem to be helpful and fundamental to knowledge management in this institution [16]. In the event of any undertaken action, the access to a variety of data on individuals, groups, and ongoing projects is most important. In addition, it is noteworthy that the databases should contain already developed and released cases, best practices, serving as a support and inspiration.

Command Support System (*System Wspomagania Dowodzenia*)[3] is an extremely powerful technology platform that solves common operational problem for emergency commanders operating at the Municipal Crowd Management department. It has been implemented in the Police in 2012 and successfully works across a wide variety of actions. The Command Support System delivers robust functionality, including [19]:

- supporting duty services in decision-making, allocation of manpower and resources,
- ensuring police response time on the received notification,
- increasing the efficiency of police work,
- ensuring regular access to information for all duty service, prevention forces, and traffic service,
- automation of the activities through the introduction of electronic registration of entries,
- providing mobile access to system resources,
- unification method of documenting activities.

The Command Support System works across a wide variety of databases held by the police. Integrates and facilitates interoperability between: duty officers of Municipal Police and other public safety dispatchers, transport dispatchers, duty officers of the county police stations, pedestrians and motorized patrols, and the prevention forces. In addition, significantly, the internal algorithm system independently performs gradation orders. There is a constant work to enhance collaboration in the system network as well as develop an interface integrating the Command Support System with the Provincial Information System for Emergency Information Centers. This system is an integral part of the created Emergency Notification System which forms integrated systems of such services as the Police, State Fire Service, State Emergency Medical Services and Location and Information Platform with a Central Database (PLI CBD) system supports immediate location of a place from which a call to an emergency number was made, which was of great importance at Euro 2012 [17, p. 33].

In the case of activities that require action on a broader scale, there is an additional separate room with modern equipment and a separate point of command at disposal. A helicopter and Mobile Monitoring Center in the form of a bus equipped with cameras and specialized hardware is also always accessible, and can be successfully used as a mobile police station [see 2]. It should be emphasized that the duty officer has access to all databases of the section staff and may at any time monitor their conversation. All dispatchers are connected to the internal network and are able to draw the necessary information from base-knowledge to facilitate the appropriate response to the collected submissions and more efficient exchange of information between each other.

Another very interesting technology supporting knowledge management processes is the National Police Information System (*Krajowy System Informacyjny Policji – KSIP*), which has been implemented since the beginning of 2003 as the central information collection obtained by employees or officers of all police organizational units in the course of official duties. "The National Police Information System is functioning in the Police Data Transmission Network (*Policyjna Sieć Transmisji Danych; PSTD*) which is a separate network not connected with another external network infrastructure such as the Internet. Access to the National Police Information System is available via computers connected to the Police Data Transmission Network equipped with hardware protection precisely identifying the user." [3, 8]. The National Police Information System platform also provides access through the required permissions for user identification card to the National Crime Information Center. This system is run by the Chief of Police of the Ministry of Interior Affairs. The National Police Information System (NPIS) consists of several modules, for example, Application NPIS WWW and Application NPIS Emergency.

[3] Command Support System by WASKO is a multi-purpose platform supporting the operation of rescue coordination centers and law enforcement in such areas as receipt of notifications and event handling, processing the input information, and alerting the appropriate disposition of forces and means as well as visualization, collection and processing of data from a variety of devices and systems. Command Support System provides full support for command centers operating in one building, room and distributed to centers. See more on the website: accessed July 2013, http://www.wasko.pl.

The first two modules allow reading and recording of collected and processed information in the National Police Information System but NPIS Emergency application might be used in the case of breakdown or lack of access to NPIS applications. It makes it possible to inquire NPIS about persons, vehicles, documents, and things. The special so-called analytical system is also functioning and should be understood as the functionality of IT systems of the National Police Information System that performs the task of creating reports, analyzes, selection or compilation of information, including personal data, based on the selected system information processed in the NPIS database sets [15].

The widely used Municipal Crowd Management database is also referred as the NCCI (National Criminal Information Center), which is a register that stores all the data needed by law enforcement institutions. This massive database contains information from 18 sources, including the Border Guard, customs, social security, the Commission for Banking Supervision, the Securities and Exchange Commission. Because of its capacity and resources it is often broadly used. The POSIGRAF database (Police Graphical Information System) should be also mentioned. This system allows the registration as well as a presentation of photos of wanted or missing persons, unknown or unknown corpses, offenders, special characters photos (such as tattoos) or facial composites. This data previously scanned and entered into the database facilitate typing suspects, perpetrators, or identification of missing or deceased persons. A similar work is ascribed to a professional database AFIS (Automated Fingerprint Identification System), used for automatically matching one or many unknown fingerprints against a database of known and unknown prints identifying a person suspected of committing a crime. Unfortunately, its application is limited by tight legislation mentioned in the previous paragraph. It is said that "the lack of systematic database feeding by investigative service makes it obsolete and inadequate in relations to registered offenders." [10, pp. 12]. Despite the huge potential, therefore, the value of the base does not meet expectations but the reasons are stuck, as observed in previous section, outside the organization.

For the purposes of numerous police activities, a human intelligence (frequently abbreviated HUMINT) and open-source intelligence (OSINT) are used to collect information from human sources. It is intelligence where the term "open" refers to overt, publicly available sources (e.g. media) [1, pp. 143-144].

The Schengen Information System (SIS) is the latest generation system that consists of three main components: the central system, the national systems of states belonging to the Schengen area, and the infrastructure linking the central system with national. This second-generation system tended to maintain and distribute information on individuals and pieces of property of interest within the European Union[4]. "SIS II offers more options, such as the possibility of introducing biometric data (fingerprints and photographs), comes with new types of notifications (e.g. stolen planes, boats, containers or means of payment). It also offers the opportunity to associate with each different entries (e.g. on the person and the vehicle). European arrest warrants are in the system connected directly to the information on persons wanted for arrest and surrender or extradition, so that the responsible authorities may take more quickly and efficiently all the necessary actions. SIS II meets the strict requirements for data protection. Access is strictly limited only for national authorities responsible for border controls, police and customs authorities, the judiciary, offices issuing visas and dealing with the registration of vehicles." [4]. Polish police have begun in 2007 to connect to the second version of the system.

The Municipal Crowd Management also relies on PRIM (Police Record Mass Events) that includes information about the dates of these events, their organizers, sport clubs, fans, fun clubs, breaches of security and public order, disorderly conduct, the venues where mass sporting events are organized, moving of the participants of mass events, and additionally, relevant foreign institutions to cooperate.

Very functional is also ARTR application (Automatic Number Plate Registration) presented in an interview. It is a program that captures an image of cars in the moments when passing near one of the city's cameras. Then by entering the registration number of a specific car, it is possible to determine the exact day it was stored in a single location, in which direction was going, how fast, and in some situations the driver of the indicated car.

[4] Everyone in this unit can see and make an adjustment to the data.

The discussed department in this article is a place of continuous learning where the convictions of a constant need for development prevail. Technological and comprehensive thinking is clearly noticeable and the ability to embrace a holistic relationship between the participants in a particular project is also present. Conviction of its own imperfection, simultaneous desire for self-improvement, the pursuit of even better decisions and excellent command and constantly searching for opportunities to introduce more modern solutions and greater use of already owned contribute largely to a high degree of organizational maturity in the Municipal Crowd Management.

It is noticeable that there are so many conscious attempts to meet the requirements associated with market needs in the context of the creation of intelligent organizations and knowledge management in the Municipal Crowd Management. With the presented (important for this study) technological improvements and tools, we can create a well-functioning advanced network technology strongly supporting knowledge management in the police. Many of these solutions also support processes of acquiring information and processing them into useful and necessary knowledge, storing data, and protecting resources. Subsequently, the distribution takes place where the resources are subject to further processing and are transformed into a qualitatively different knowledge. The use of the available information and newly created knowledge develops and strengthens the experience and competence of the employees. It is impossible to draw a clear line between these systems and earlier discussed individual processes of knowledge management model in the police. It seems that it emerges from the specific character of the organization, which is precisely the police.

Specialists equipped with described techniques and technologies, tools, applications, and hardware may help to achieve much more than they perform but are often limited from outside by the regulatory framework, inadequate state funding, poor approach to the advantages of implementing some solutions or lack of formal authorizations for certain activities. It seems that the mere possession of tools and willingness to create something of value is insufficient and therefore, we should heighten awareness and put more emphasis on the agreement how to use this potential.

It can be concluded from the available legal opportunities and technological solutions that the police operations are achieving high effectiveness. We can observe the beginning of implementation of knowledge management system in terms of both philosophy and information and technology resources supporting operations of the entire unit. The Municipal Crowd Management takes a clear attempt to connect the hardness of management in hierarchical organizations with a soft concept, which is the management of knowledge.

In this place, it is worthwhile to bring in public opinion about discussed services that reflect the effectiveness and legitimacy undertaken by this department services. It should be recalled that the 2012 UEFA European Championship, commonly referred to as Euro 2012, was hosted by Poland, which was an enormous undertaking generating different types of threats. The performance of Municipal Crowd Management Department in association with other Departments during Euro 2012 has been rated very positively. According to research conducted by PBS, 84.2% of Poles believe that the organization of the tournament has contributed to the safety improvement and functioning of the police. Public opinion is a great motivator for continuous investment in development of national security, which should be secured by care and development of existing technological facilities to streamline police operations. Development of Knowledge Based Economyin Poland gives an example of adopting such measures that in consequence allows creation of e-government, e-state, numerous improvements in terms of EU and global requirements, technological change, and social progress. It is important to take utmost advantage of the capabilities and competence of experienced people, financial resources, and legal opportunities; making efforts to modernize faster and create conditions for better and more pro-social functioning of public services, namely, the Police Forces.

4 Summary

In response to the market challenges and social change, it should be agreed that the implementation of the assumptions of the intelligent and knowledge-based organization in the public sector could raise their level of organizational maturity, effectiveness, and efficiency.

The key to the successful implementation of major features of this concept is the awareness of the employees as to the validity of the changes and the desire to make effort to modify certain rules, sometimes existing since many years.

In the described case, we can see several places where the model of a knowledge-based organization is being used. Wherever there are financial possibilities and despite all constraints imposed by the specific nature of this organization a strong hierarchy, efforts are undertaken aiming to change this institution into a modern and open one, which will take care of the security and peace of society, while sustaining a high levels of prevention. This kind of institution will therefore become a more severe opponent in the ring of reality, both real and virtual for individuals, groups, or organizations that are deemed to constitute a threat to the stability and safety of citizens and the state.

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